Railway Mechanical Engineer

Founded in 1832 as the American Rail-Road Journal
With which are also incorporated the National Car Builder, American Engineer and Railroad Journal, and Railway Master Mechanic. Name Registered, U. S. Patent Office

May, 1935

Volume 109 *No. 5*

Published on the 26th day of the month preceding the date of issue by the

Simmons-Boardman Publishing Company

1309 Noble St., Philadelphia, Pa. Editorial and Executive Offices,
30 Church Street, New York, N. Y., and 105 West Adams Street, Chicago, Ill.

Cleveland: Terminal Tower
Washington: 832 National Press Bldg.
San Francisco: 55 New Montgomery St.

Subscriptions, including 12 regular monthly issues, payable in advance and postage free. United States and possessions: 1 year, $3; 2 years, $5. Canada, including duty: 1 year, $3.50; 2 years, $6. Foreign countries: 1 year, $4; 2 years, $7.

This is to certify that the average circulation per issue of *Railway Mechanical Engineer* for the six months period July 1 to and including December 31, 1934, was as follows: Copies sold, 3,815; copies distributed free, 335; total 4,150. Signed, H. E. McCandless, Circulation Manager, Simmons-Boardman Publishing Company. Subscribed to and sworn before me on this 12th day of April 1935. Henry D. Nelson, Notary Public, Queens County, N. Y.

The Railway Mechanical Engineer is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. B. C.) and is indexed by the Industrial Arts Index and also by the Engineering Index Service.

Railway Mechanical Engineer

Founded in 1832 as the American Rail-Road Journal

May - 1935

Light-Weight Passenger Trains For the Baltimore & Ohio

Two trains of eight cars each, one of Cor-Ten steel, the other of strong aluminum alloys, effect large savings in weight

LAST year the Baltimore & Ohio placed an order with the American Car and Foundry Company for two eight-car passenger trains, one train to be constructed of U.S.S. Cor-Ten steel and the other of strong aluminum alloys. The first train, built of steel, has been completed and will be placed in service on the Alton between Chicago and St. Louis, Mo., on July 1. It has been named "The Abraham Lincoln" and will make the run of 284 miles, one way, in approximately five hours, leaving St. Louis in the morning and returning in the afternoon. The second train, built of aluminum, will be delivered at an early date. The service to which it will be assigned has not yet been announced.

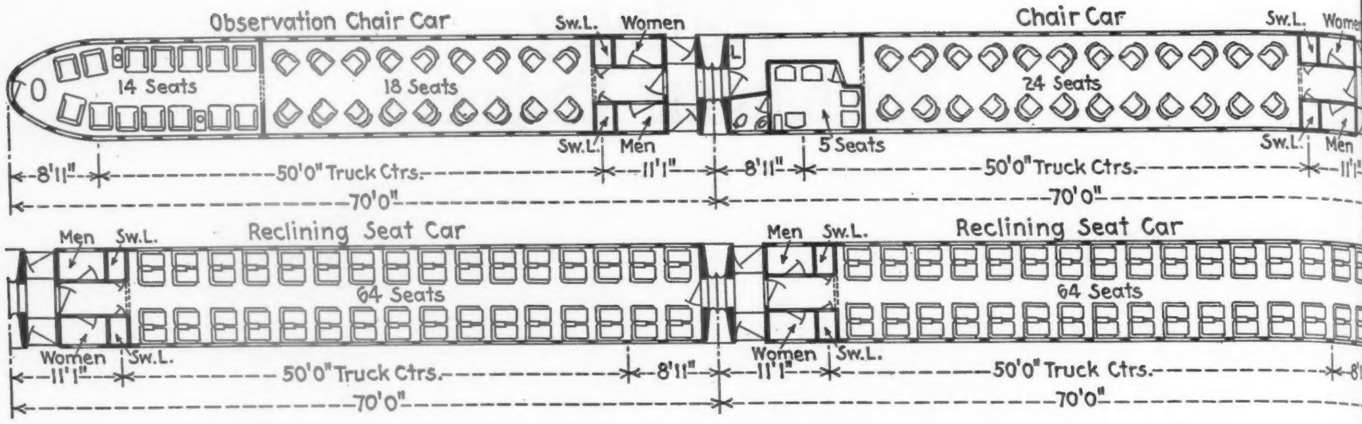
The two trains are of similar construction, and include cars of five types, namely, one mail and baggage car, three reclining-seat cars, one combination diner and lunch car, two chair cars and one observation-chair car. Each eight-car train is 557 ft. 10 in. long and has a total seating capacity of 283, exclusive of the dining and lunch car which provides seats for a total of 42 persons. Flexibility is provided by the non-articulated construction which permits cutting out one or more cars and operating trains of six, seven or eight cars as required.

Referring to the table of comparative weights, it will be noted that the Cor-Ten-steel train weighs 780,800 lb., or 40 per cent less than an equivalent train of conventional steel construction which would weigh about 1,300,000 lb. The aluminum-alloy train weighs 699,540 lb., or 46.5 per cent less than an equivalent conventional steel train. These figures, however, do not give an entirely accurate measure of the respective weight-reduction possibilities of the two materials, since considerable aluminum, for such parts as interior finish, air ducts, insulation, metal closures between cars, etc., is used in the steel train and steel, for such parts as center sills, buffer castings, truck castings, etc., is used in the aluminum train. For a direct comparison, reference to the table will show that the actual shell weight of each of the five types of aluminum-alloy cars is about 30 per cent less than that of the Cor-Ten steel car.

Duryea Cushioned Underframes—Other Special Features

All cars are equipped with Duryea cushioned underframes, a type of construction which permits center

One of the Baltimore & Ohio light-weight high-speed trains from the observation end



Both trains have the

sills to move 4 in. in either direction from normal through the car body. The sill is anchored to the bolster center filler castings, through which it passes, by springs, links and pins. If the car body moves or changes its relation to the center sill, the spring gear instantly cushions the movement.

Couplers are O-B Tight-Lock A.A.R. type, slightly modified for application to these cars since the Duryea cushioned underframe eliminates the necessity of providing a friction-type draft spring usually required within the shank of this coupler. The coupler, with rigidly attached connector head, automatically provides steam, air and electric connections between the cars. Since electric signaling is used on these trains the air signal line is eliminated. The couplers, when in the coupled position, are tightly locked against vertical, lateral or longitudinal movement between coupler faces, all slack or lost motion being eliminated. This contributes to smooth train handling. It is also designed to prevent telescoping in the event of derailment.

Weights of B. & O. Cor-Ten Steel and Aluminum-Alloy Cars Built by American Car and Foundry Company

	Mail—Baggage		Reclining Seat		Dining—Lunch		Chair Car		Obs.—Chair Car	
	Cor-Ten	Alum.-alloy	Cor-Ten	Alum.-alloy	Cor-Ten	Alum.-alloy	Cor-Ten	Alum.-alloy	Cor-Ten	Alum.-alloy
Shell weight, lb.	33,680	22,920	33,920	23,520	33,340	22,920	33,920	23,520	31,760	22,020
Body light wt. (est.), lb.	61,580	51,040	72,900	62,700	75,930	65,760	72,500	62,300	66,800	57,250
Trucks, weight, lb.	25,520	25,520	24,600	24,600	25,520	25,520	24,600	24,600	24,600	24,600
Total light wt. (est.), lb.*	87,100	76,560	97,500	87,300	101,450	91,280	97,100	86,900	91,400	81,850
Water, ice, provisions, etc.	350	350	1,300	1,300	6,000	6,000	1,300	1,300	1,300	1,300
Wt. ready for service (est.), lb.	87,450	76,910	98,800	88,600	107,450	97,280	98,400	88,200	92,700	83,150

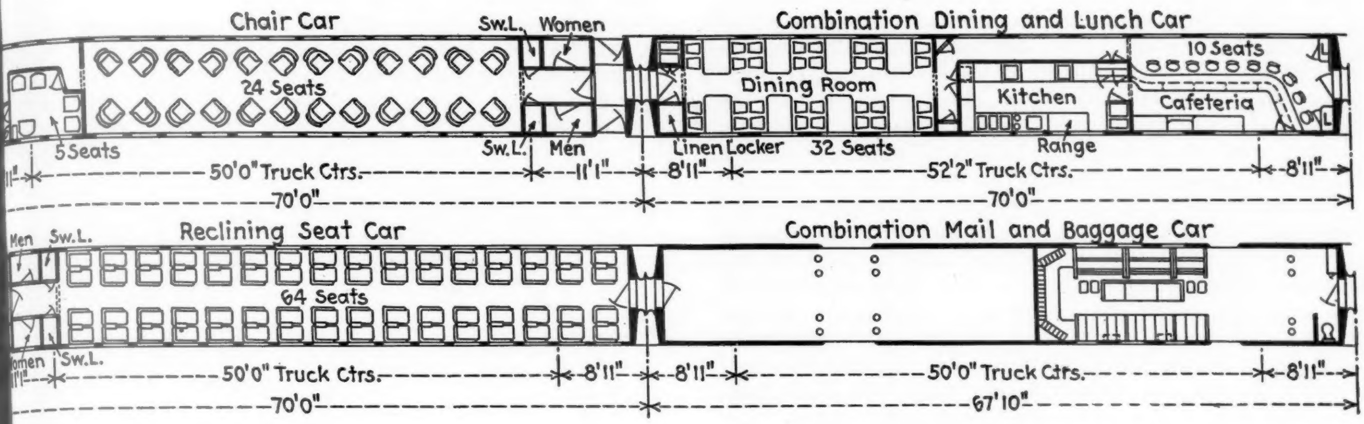
Total weight of Cor-Ten 8-car steel train—780,800 lb.
Total weight of aluminum-alloy 8-car train—699,540 lb.
Total weight of equivalent train of conventional steel construction—1,300,000 lb.

* Estimate includes about 6,800 lb. weight of Duryea center sill and attachments and approximately 5,000 lb. for air-conditioning and heating equipment on passenger-carrying cars.

Interior of one of the cars showing typical Cor-Ten steel framing and sheathing

The signal system is the National Pneumatic two-wire, button-control type, so connected that when the buzzer sounds in the locomotive, the tell-tale buzzers at push buttons in the cars will sound. Telephone communication is also available between the baggage room and the locomotive cab.

The trucks are A.C.F. light-weight, single-equalizer, four-wheel type. The truck frames and bolsters are of Lebanon Circle L2 electric cast steel, a manganese-chrome-molybdenum alloy which has a tensile strength of 100,000 to 115,000 lb. per sq. in. and a yield point of 70,000 lb. to 80,000 lb. The trucks are equipped with B. & O. spring snubbers and Simplex Unit-Cylinder clasp brakes with automatic shim-type slack adjusters. The wheels are Armco 33-in., light-weight, rolled-steel with Emerson-Tatum machined treads. Timken roller bearings are applied on the steel train and Hyatt roller bearings on the aluminum-alloy train. Hardened-steel wear plates are applied where necessary and Oilite discs reduce center-plate friction and wear. Particular attention has been paid to truck cushioning. Felt pads are applied under the center-plate, side bearings, at bolster ends, etc., and special molded rubber cushions are applied in equalizer spring seats and caps and at the ends of the elliptic springs. This construction breaks the metallic



...ngement of interior facilities

contacts and retards the transmission of rail vibration and sounds to the car body.

In general, the steel car bodies are insulated with Nicolfelt and Alfol and the aluminum-alloy car bodies with Johns-Manville light-weight Salamander. Cork insulation is used in the floors of both trains. A feature of unusual interest is the window construction, which includes fixed outer polished plate glass and a piano-hinged inner sash with Duplate shatter-proof glass, which may be swung open for cleaning purposes.

Both trains are air-conditioned, using the Baltimore & Ohio standard system, which incorporates the York compressor and a new method of air distribution whereby cool air from a center ceiling duct settles downward and is drawn into two floor ducts, one at each side of the car, then returned to the air-cooling unit, united with a certain proportion of fresh air, cooled and recirculated. For heating, this circulation is reversed, warm air which has passed over heating coils in the two separate heating units entering the car through the floor ducts and being returned through the ceiling ducts. Humidity conditions are held within desired limits when either cooling or heating the cars. Motor-operated dampers and regulating valves are thermostatically controlled.

Quick-service Schedule UC4-8 air-brake equipment was furnished by the Westinghouse Air Brake Company for the steel train and by the New York Air Brake Company for the aluminum train. Universal hand brakes, operating in connection with the Peacock power-increasing device, are installed on both trains, the hand braking effort being applied to one truck only of each car.

General Construction Features—Steel Car Details

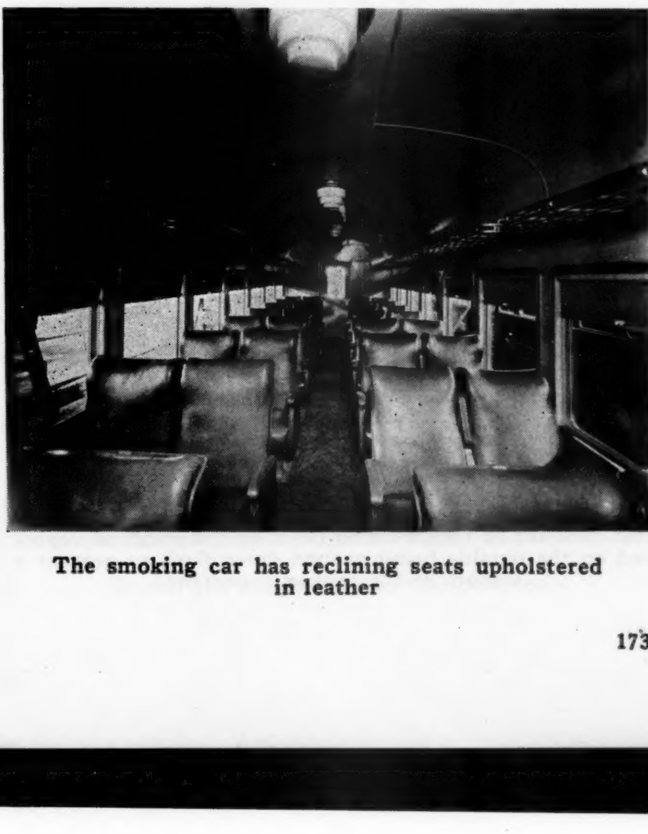
The car bodies of the B. & O. light-weight high-speed trains are of more or less conventional design, no attempt having been made to utilize the tubular construction employed in some recent streamlined trains. In these cars the necessary bulk of material is placed in the underframe and superstructure to assure adequate strength, and yet, owing to the use of relatively strong or light structural materials, a material weight reduction is effected. Practically the same structural design is used in both steel and aluminum-alloy trains, with the exception that certain aluminum-alloy members are increased in cross-sectional area to keep deflection within required limits, and certain changes are necessary in rivet spacing. The most noticeable difference between the

Principal Dimensions and Seating Capacities of Passenger Cars in Two B. & O. Light-Weight Trains

No. of cars in each train	Type of car	Length over buffers, coupled (ft. in.)	Width over sheathing (ft. in.)	Roof height above rails (ft. in.)	Truck center distance (ft. in.)	Truck wheel-base (ft. in.)	Journals (roller brg.) dia. & length (in.)	Seating capacity per car	Total seating capacity
1	Mail and baggage	67—10	9—9½	12—7 7/16	50—0	7—0	5 by 9		
3	Reclining seat	70— 0	9—9½	12—7 7/16	50—0	7—0	4¼ by 8	64	192
1	Diner and lunch	70— 0	9—9½	12—7 7/16	52—2	7—0	5 by 9	32 diner 10 lunch	42
2	Chair car	70— 0	9—9½	12—7 7/16	50—0	7—0	4¼ by 8	24 compt. 5 dwg. rm.	58
1	Observation chair	70— 0	9—9½	12—7 7/16	50—0	7—0	4¼ by 8	18 compt. *15 parlor	33
	Total coupled car length of each 8-car train 557 ft. 10 in.							Total seating capacity of each 8-car train	283†

* Includes desk chair.

† Not including dining-car seats.



The smoking car has reclining seats upholstered in leather

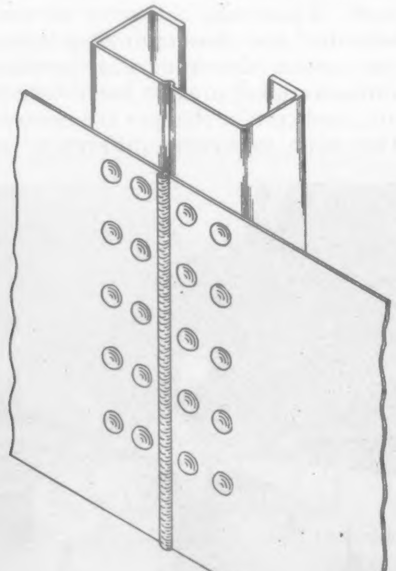
steel and the aluminum cars, when viewed from the outside, is the provision of three instead of two rows of rivets at the side sill. The steel cars are built with ¾-in. camber and, when uniformly loaded to capacity, have a maximum deflection of ¼-in. at the center. In the case of the aluminum cars, they are built with 1⅛-in. camber and, when similarly loaded to capacity, have a maximum deflection of ⅜-in.

The underframe of each steel car, including the Duryea center sill, is built of U. S. S. Cor-ten steel, having a yield point of 50,000 to 60,000 lb. per sq. in. and improved rust-resisting qualities. The light-weight steel castings required in the design are of Lebanon manganese-chrome-molybdenum steel of the same properties as that used in the truck castings. The car frames comprised a riveted and welded design with 9-in. ship-channel center sills, ¼-in. pressed-channel torque arms, 3/16-in. pressed-pan body bolsters, 3-in. Z-bar cross bearers, 7-in. channel end sills and alloy-steel buffer beams. The side sills are 5-in. rolled angles; side posts, 3/32-in. pressed channels; sheating, No. 13 U. S. gage hot-rolled sheets, riveted in place, without lap joints, and welded at the seams. The roof construction utilizes 13-gage, pressed-channel carlines and pressed Z purlines connected by welding, with roof sheets made of 16-gage U. S. S. Cor-Ten sheets, riveted and welded.

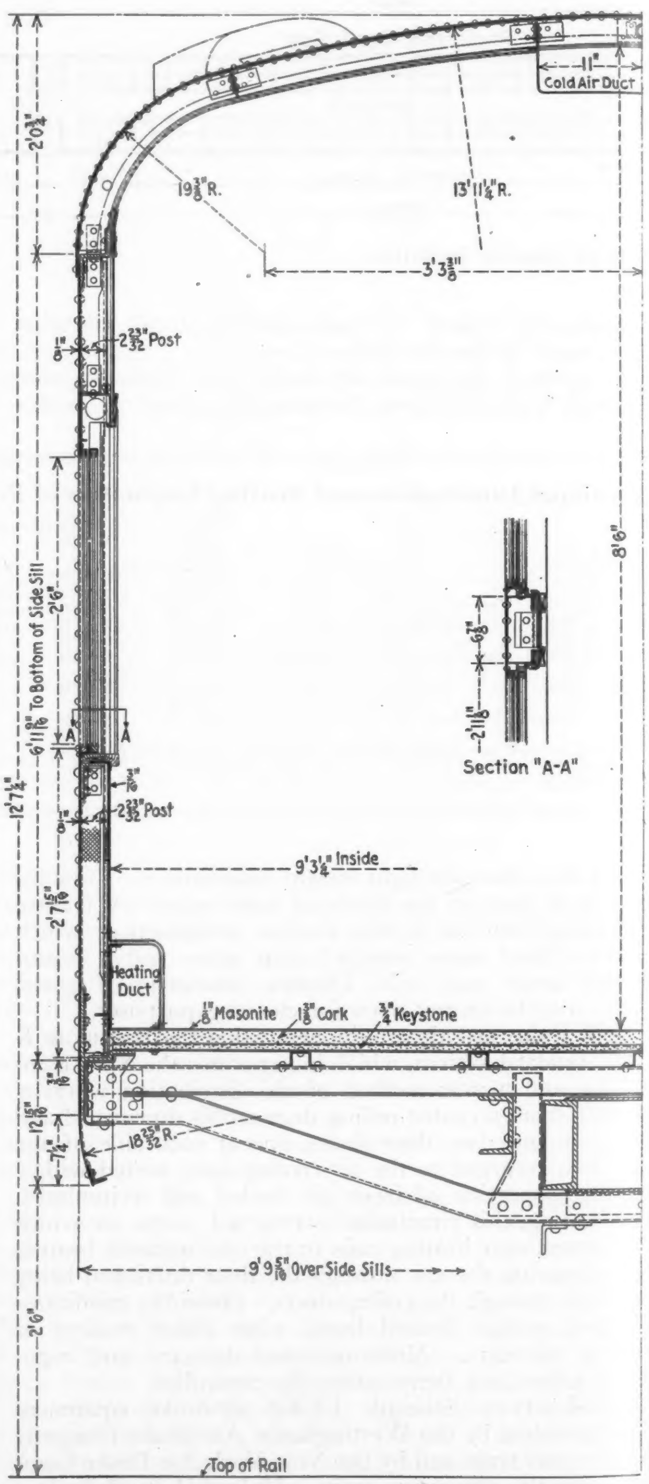
The floor construction employes Keystone 16-gage aluminum floor sheets, installed crosswise and riveted to floor supports. Cork insulation is applied and Masonite tempered Presdwood cemented over the entire floor. Inside finish below the windows is 3/16-in. Presdwood and, from the window capping to the side plate, 3/16-in. Haskelite aluminum-face Plymetl. Ceilings are also of this material. Wash-rooms are finished with 3/16-in. green Asbestos Waltile.

Construction of the Aluminum-Alloy Cars

Each aluminum car underframe, with the exception of the Duryea center sill, is built up of strong aluminum alloy extruded shapes and formed sheets. The side sills are extruded shapes designed to give the necessary cross-section and permit easy assembling. The bolsters are built up of top and bottom cover plates of strong aluminum alloy, separated by pressed pans of aluminum sheets, joined with steel rivets. Cross bearers or floor supports are Z-bars extruded in strong aluminum alloys as top and bottom members, connected by pressed pans of aluminum sheet. The floor stringers, running the length of the car, are extruded wing channels of strong aluminum alloy. At each end of the underframe, pressed pans of strong aluminum alloy connect the end sills of the cars to the bolsters and serve as torque arms in connection with the Duryea center sill. The underframe is assembled with steel rivets.

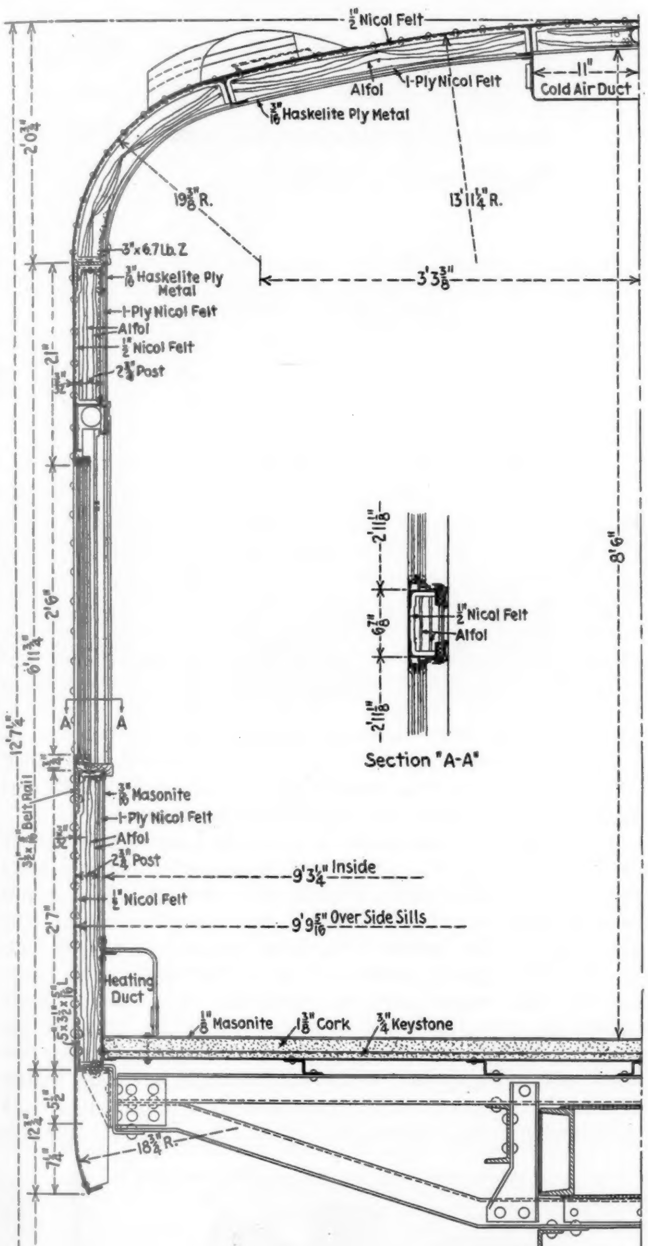


Aluminum car side post and side sheet joint—Extruded post recessed to take welding bead, excess material deposited on the outside being ground down flush to present a smooth and unbroken appearance



Typical cross section of an aluminum coach

The sides of the cars are framed with two different types of side posts, these being extruded sections of strong aluminum alloy. One is a narrow post which is used at blank panels and the other is the main window post. The latter is wide and has a special groove to facilitate making a butt weld in the side sheets. The



Cross section of a coach with Cor-Ten construction

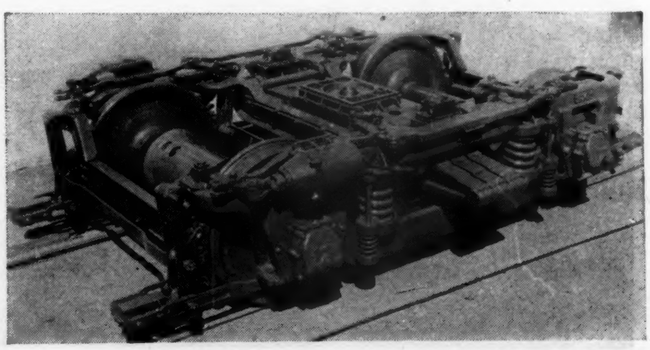
side plate is an extruded shape, especially designed to connect the posts and carlines with the letter board and roof sheets. This side plate and the side sills are excellent examples of the combination in an integral member of a number of shapes by the extrusion process.

The side sheets are particularly interesting from a carbuilding standpoint in that they consist of extra wide sheets of strong aluminum alloy, stretcher-leveled so as to make one smooth sheet from the eaves to the skirt of the car. The length of these is such that in the majority of cases only four sheets are necessary for one side of a car. These sheets are joined together with edges butted on the large side posts, the joint in the sheets coming directly over the small groove in the center of the posts. Electric arc welds are run from end to end of this joint, flowing the metal together and anchoring it in the small groove, also forming a bead on the inside of the sheet. This construction allows the outside aluminum sheets to be dressed perfectly smooth without danger of attendant weakening of a dressed weld. The whole effect is an extremely smooth exterior appearance, the only protuberances being the rivet heads.

The belt rail is an extruded shape of strong aluminum alloy. It is so installed as to form the base for the sashrest section. Sash are of steel drawn shapes, assembled and fitted with glass by the Hunter Sash Company. The car roof is built up of a one-piece channel-shaped aluminum sheet pressing as a carline. These carlines run from side plate to side plate and are securely fastened together longitudinally by four lines of purlines made from pressed aluminum sheet. The roof sheets, which are riveted to these carlines, are of aluminum alloy, with suitable provision for waterproofing at all joints. The ends of the cars are aluminum-alloy sheets with anti-telescoping reinforcements of aluminum-alloy rolled angles and plates.

The car interiors are of aluminum construction. The side and head lining is Plymetl with aluminum sheet glued to laminated wood. The various bulkheads, doors, trim and ducts for air-conditioning are of aluminum-alloy sheet. Where Plymetl is used it is applied with screws. Special small extruded channels and angels of strong aluminum alloy are used as reinforcements and framing of the interior finish. All rivets used in the assembly of the interior finish where welding was not possible are of aluminum alloy. The interior-trim hardware, as well as that in the kitchen, on the doors, windows, seats and basket racks, are aluminum castings.

A continuous line without the usual openings between cars being desired, it was necessary to design a closure to cover the space between the cars. Aluminum-alloy rolled channels and angles form the framework of the movable portion of this closure, with sheet pressed to shape for the covering and bearing surfaces. The closure is well braced and forms a unit with the diaphragm face plate. The complete assembly is connected to the buffer which extends the full width of the car and is equipped with two 2¼-in. round stems, spaced 28⅜-in. on either side of the center line and operating through rubberized sleeves. These stems move inward under spring pressure which, in conjunction with the semi-elliptic upper buffer spring compression, is adequate to keep the face plates in contact when the cars are coupled under all conditions, including a 20 deg. curve.



One of the trucks used on the steel train

Baltimore & Ohio Builds Two High-Speed Locomotives

New designs of 4-4-4 and 4-6-4 types have 84-in. drivers, water-tube fireboxes and 350-lb. pressure boilers

THE Baltimore & Ohio has designed and built at the Mount Clare shops, Baltimore, Md., two locomotives of radically new design which are to be used to haul trains of light-weight streamlined passenger cars on fast schedules. Two special trains of eight cars each are being provided, one constructed largely of Cor-Ten steel weighing approximately 390 tons, and the other in which aluminum alloys are employed weighing about 350 tons. One of the trains will be placed in service on the Alton between Chicago and St. Louis about July 1, while the other may later be operated between New York and Washington.

The smaller locomotive, which has a 4-4-4 wheel arrangement, road No. 1, class J-1, has been named "Lady Baltimore." The larger locomotive, which has a 4-6-4 wheel arrangement, road No. 2, Class V-2, has been named "Lord Baltimore." The first weighs 217,800 lb., exclusive of the tender, and the second, 294,000 lb. Both have 84-in. drivers. A striking feature of these locomotives is the boiler which embodies the Emerson water-tube firebox and carries 350 lb. steam pressure.

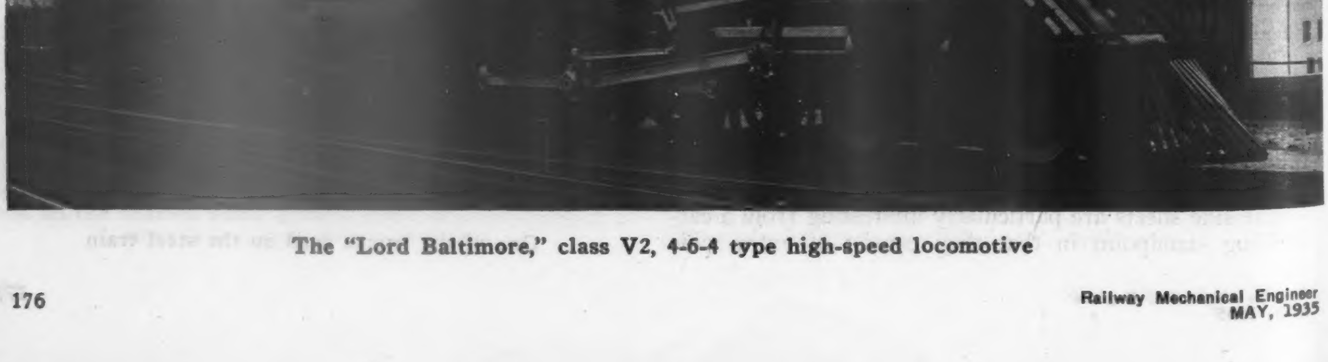
The 4-4-4 type locomotive has 17½-in. by 28-in. cylinders and develops a tractive force of 28,000 lb., while the 4-6-4 type locomotive has 19-in. by 28-in. cylinders and develops a tractive force of 34,000 lb. The high-speed trailer boosters with which both locomotives are equipped add, at low speeds, 7,000 lb. more to the tractive force of each locomotive. The smaller locomotive is estimated to develop a maximum sustained cylinder horsepower of 1,810 with a boiler estimated at 1,990 hp., and the larger one a maximum of 2,200 cylinder-horsepower with a boiler estimated at 2,660 hp., these calculations being made on the general basis of Cole's ratios.

Both locomotives have hauled test trains of about 250 tons, which is approximately equal to the weight of trains consisting of six of the new light-weight coaches. When operating on schedules of about 60 m.p.h., and including regular express station stops as well as operating checks and speed restrictions, both have demonstrated their ability to meet schedule requirements with top speeds rarely exceeding 80 m.p.h. This result was possible because of the high rate of acceleration at medium and high speeds. The class J-1 locomotive, which was completed in September, 1934, has already been in service on several divisions of the Baltimore & Ohio system, and has made some exceptionally fast runs on the Chicago division. At 95 m.p.h. it developed 1,570 drawbar hp. with a tractive force of 6,195 lb.

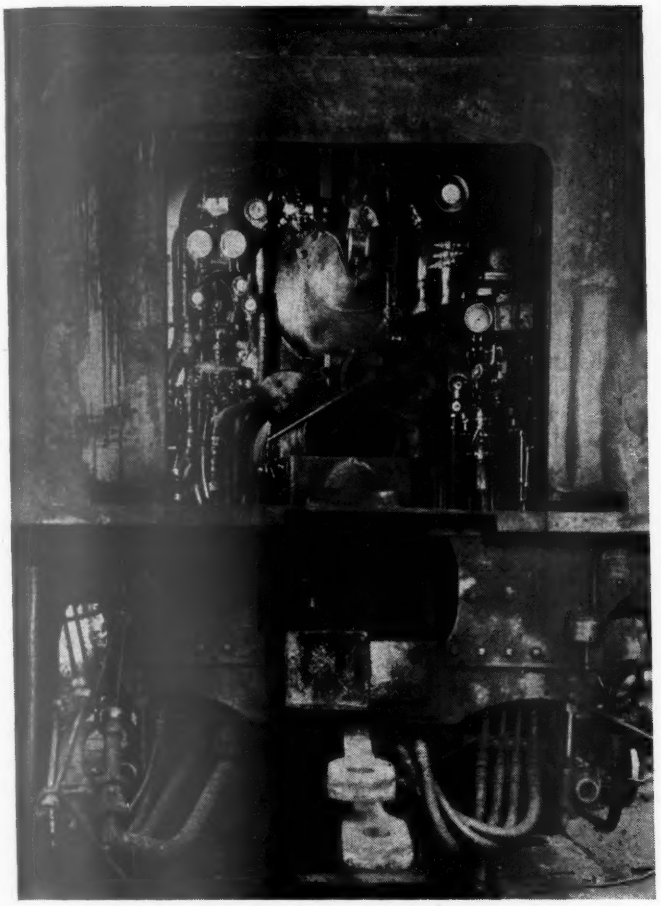
Boilers Have Emerson Water-Tube Fireboxes

The boilers of both locomotives are designed for 350 lb. working pressure and are similar in construction to the boilers on the experimental locomotives of the 4-8-2 and 2-6-6-2 types described in the *Railway Mechanical Engineer* August, 1931, page 397. The barrels are of conventional type with 2¼-in. fire tubes and 5½-in. flues. At the back end the barrel terminates in a stayed water-leg with throat and back tube sheets which forms the front of the firebox. The back end of the firebox is also a stayed water-leg and in general construction resembles the ordinary back-head of a conventional boiler. The staybolts in the water-legs are of such length and location as to avoid the usual breakage zone.

Above the firebox there is a single longitudinal drum, 36 in. in outside diameter, which projects into the upper part of the boiler shell to which it is connected by means of a flanged hip sheet. The drum extends forward into the shell of the boiler 4 ft. 8 in. beyond the back tube sheet. The upper portion of this extension is cut away, leaving the lower part in the form of a trough from which the top circulation is delivered to the barrel of the boiler. At the rear end the drum is carried through the back water-leg, with which it communicates by means of circulating ports, and terminates in a bulged head. A standard manhole through the back head of the drum is



The "Lord Baltimore," class V2, 4-6-4 type high-speed locomotive



Looking inside of one of the cabs

provided for convenient use at inspection periods.

The two water-legs are connected at the bottom by headers, one on each side. These are of seamless steel and rectangular in section except at the ends, where the section changes to a circular form for attachment to the flanged openings in the headers. These headers provide for the circulation between the two water-legs and form the bottom side frame of the firebox. Top headers of similar cross-section but closed at the ends extend along each side of the drum, to which they are connected by means of horizontal nipples, rolled in. On each side between the upper and lower headers are two staggered rows of water-tubes 2¼ in. in outside diameter which are rolled into both headers.

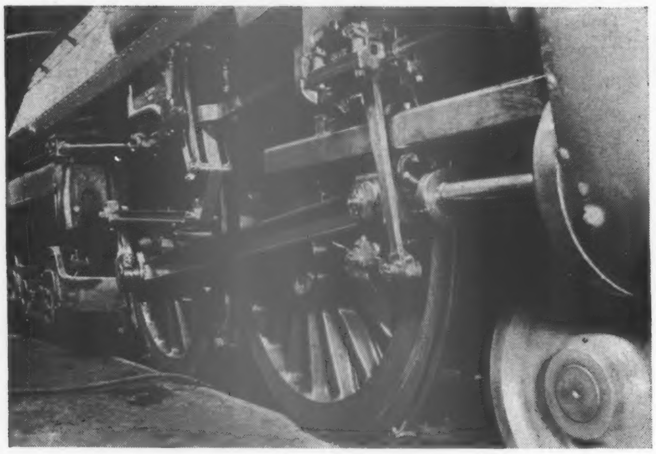
Opposite each water-tube in the top and bottom headers there is a plug opening through which the tubes are rolled. The bottom plugs are not removed during wash-outs. The plugs in the top headers are fitted with coarse threads and are easily removed. Through these openings washing and turbining operations are performed. Enginehouse time for washing the water-tube firebox is said not to exceed that necessary for the conventional staybolt type.

The side water-tubes, with their top and bottom headers, the drums, and the front and back water-legs, enclose a firebox substantially rectangular in outline which is of stayless construction except for the water legs. The firebox is enveloped and made air tight with a fire-brick covering, magnesia lagging and a steel jacket.

The first Emerson water-tube firebox was applied on a B. & O. locomotive in 1927 and since that date others have been applied, both to new and existing boiler shells. Throughout the wide experience with this type of firebox in service on all parts of the B. & O. they have proved more satisfactory than the conventional type. Their initial cost is no greater than that of staybolt fireboxes of similar size and they eliminate crown-and-side-sheet staybolts. At each wash-out the scale in the fire tubes is completely removed by turbining, thus effecting

Principal Dimensions, Weights and Proportions of the Baltimore & Ohio High-Speed Locomotives

Builder	B. & O.	B. & O.
Name	Lady Baltimore	Lord Baltimore
Road number	1	2
Road class	J-1	V-2
Type	4-4-4	4-6-4
Service	Passenger	Passenger
Height to top of stack	13 ft. 4½ in.	14 ft. 4¾ in.
Width	10 ft. 3 in.	10 ft. 1¼ in.
Cylinders, diameter and stroke (2)	17½ in. by 28 in.	19 in. by 28 in.
Valve gear, type	Walschaert	Walschaert
Valves, piston type:		
Size	10 in.	10 in.
Maximum travel	7 in.	7 in.
Steam lap	1⅝ in.	1⅝ in.
Exhaust clearance	⅛ in.	⅛ in.
Lead	¼ in.	¼ in.
Cut-off in full gear, per cent.	75	75
Weights in working order:		
On drivers	99,800 lb.	156,000 lb.
On front truck	40,000 lb.	45,000 lb.
On trailing truck, front axle.	37,000 lb.	45,000 lb.
On trailing truck, rear axle.	41,000 lb.	48,000 lb.
Total engine	217,800 lb.	294,000 lb.
Tender	170,000 lb.	199,800 lb.
Wheel bases:		
Driving (rigid)	7 ft. 5 in.	14 ft. 10 in.
Total engine	35 ft. 5½ in.	42 ft. 10½ in.
Total engine and tender	71 ft. 4½ in.	81 ft. 6½ in.
Wheels, diam. outside tires:		
Driving	84 in.	84 in.
Front truck	36 in.	36 in.
Trailing	36 in.	36 in.
Journals, diam. and length:		
Driving, main	10 in. by 13 in.	11 in. by 13 in.
Driving, others	10 in. by 13 in.	10 in. by 13 in.
Front truck	6½ in. by 12 in.	6½ in. by 12 in.
Trailing truck	7 in. by 13 in.	7 in. by 13 in.
Boiler:		
Type	Comb. fire and water tube	Comb. fire and water tube
Steam pressure	350 lb.	350 lb.
Fuel	Soft coal	Soft coal
Stoker	B. & O.	Standard (Lower)
Diameter, first ring outside	62 in.	72 in.
Firebox, length and width	159 in. by 78 in.	159 in. by 78 in.
Firebox water tubes	146—2½ in.	146—2½ in.
Grate dimensions	114 in. by 78 in.	114 in. by 78 in.
Tubes, number and diameter.	77—2¼ in.	120—2¼ in.
Flues, number and diameter.	18—5½ in.	27—5½ in.
Length over tube sheets	17 ft. 9 in.	25 ft. 0 in.
Grate type	Table	Table
Grate area	61.75 sq. ft.	61.75 sq. ft.
Heating surfaces:		
Firebox, water tubes	347 sq. ft.	418 sq. ft.
Firebox, sheets	122 sq. ft.	139 sq. ft.
Firebox, arch tubes	54 sq. ft.	55 sq. ft.
Firebox, total	523 sq. ft.	612 sq. ft.
Tubes and flues	1,257 sq. ft.	2,727 sq. ft.
Total evaporative	1,780 sq. ft.	3,339 sq. ft.
Superheating	415 sq. ft.	880 sq. ft.
Comb. evap. and superheat	2,195 sq. ft.	4,219 sq. ft.
Firebox h.s. per cent comb. h.s.	23.8	14.5
Tube & flue h.s. per cent comb. h.s.	57.2	64.6
Superheating per cent comb. h.s.	18.9	20.85
Tender:		
Style	Water bottom	Water bottom
Fuel capacity	14 tons	16 tons
Water capacity	8,000 gal.	10,000 gal.
Trucks	4-wheel	4-wheel
Wheels, diameter	36 in.	36 in.
Journals	6 in. by 11 in.	6 in. by 11 in.
General data, estimated:		
Rated tractive force, engine.	28,000 lb.	34,000 lb.
Rated tractive force, with booster	35,000 lb.	41,000 lb.
Cylinder horsepower (B. & O. estimate)	1,810	2,200
Speed at 1,000 ft. piston speed	53.55 m.p.h.	53.55 m.p.h.
Piston speed at 10 m.p.h.	186.5 ft.	186.5 ft.
Weight proportions:		
Weight on drivers ÷ total weight engine, per cent	45.8	53.1
Weight on drivers ÷ tractive force	3.56	4.59
Weight engine ÷ comb. heat. surface	99.3	69.7
Boiler proportions:		
Tractive force ÷ comb. heat. surface	12.76	8.06
Tractive force × diam. drivers ÷ comb. heat. surface.	1,072	677
Firebox heat. surface ÷ grate area	8.47	9.90
Tube & flue heat. surface ÷ grate area	20.35	44.16
Superheat. surface ÷ grate area	6.72	14.25
Comb. heat. surface ÷ grate area	35.54	68.31



The running gear and motion work of the 4-4-4 type locomotive

a high average heat transfer and improved efficiency.

The fireboxes on both locomotives are 159 in. long by 78 in. wide and are fitted with five arch tubes. The length of the grate is reduced to 114 in. by a fire wall extending up to the arch tubes. This wall and the Security arch carried on the tubes in effect divide the firebox volume into a firebox proper with 61.75 sq. ft. of grate area and a 36-in. combustion chamber. Because of the larger diameter of the boiler shell the average length of the water-tubes in the class V-2 locomotive is 6 ft. 4 in. against an average length of 5 ft. 3 in. for the class J-1. This results in a total firebox heating surface of 523 sq. ft. in the class J-1 and 612 sq. ft. in the class V-2. The fireboxes are fitted with B & O. standard table type grates which are shaken by hand.

Locomotives of both designs are equipped with stokers. That on the 4-4-4 type locomotive is of railroad design, while that on the 4-6-4 type is the Lower type. Both are of the backhead type with steam-jet coal distribution, the conveyors being operated by two-cylinder reciprocating-type engines mounted on the tender.

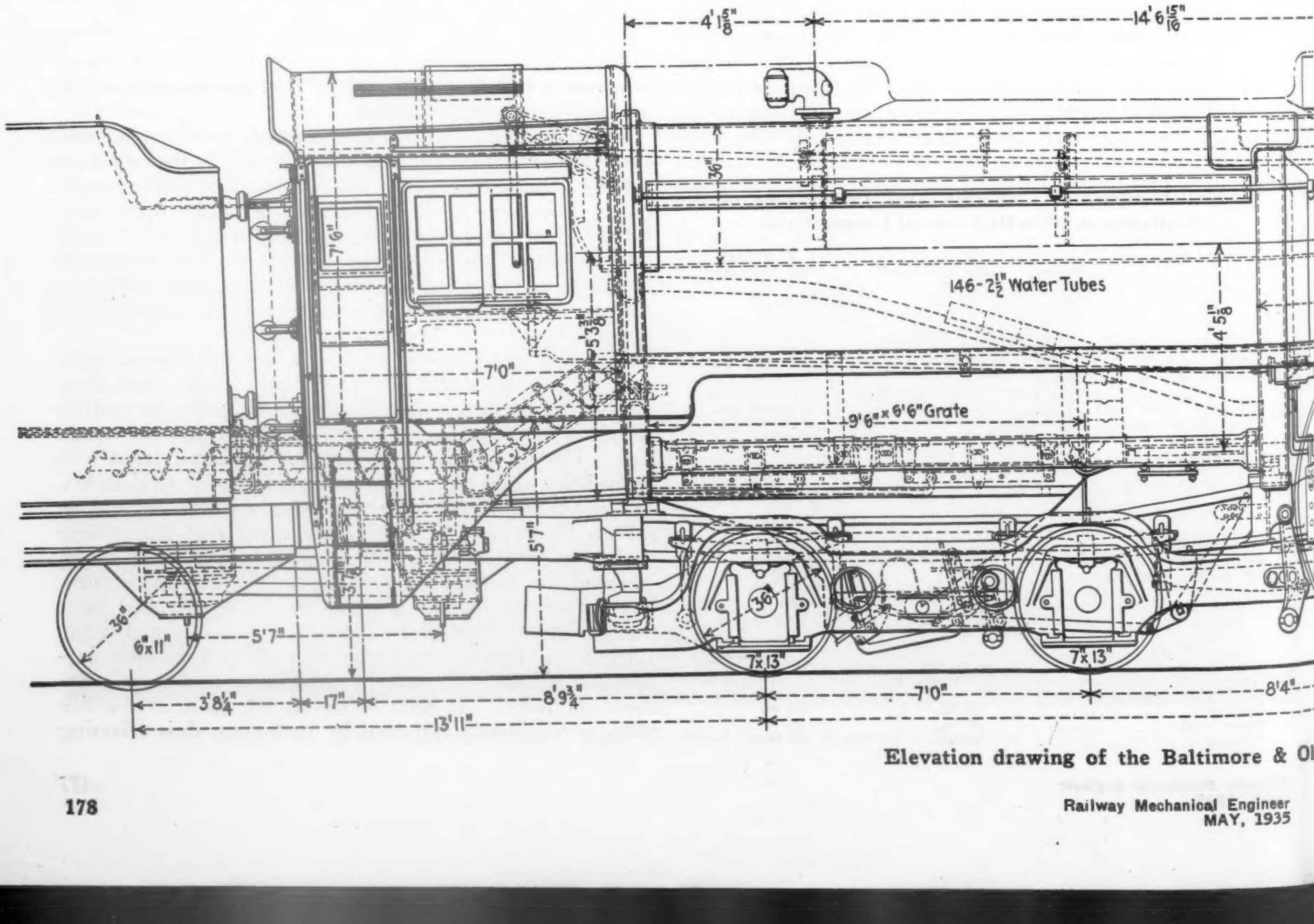
The superheaters, built by the railroad, have headers fabricated from rolled plate by welding and units rolled into the headers. There are 18 units in the smaller boiler and 27 in the larger. The boilers are fed by Hancock non-lifting injectors designed for operation with high-pressure steam. The check valves are located on the side of the boiler near the front tube sheet.

A noticeable feature of these locomotives is the front-end door from which the usual multiplicity of clamp bolts is absent. The doors are secured by a single lock and clamp similar to those applied in British practice. Two yokes which span the inside of the door opening at right angles are slotted to receive the tee-head of the clamp bolt which is turned by the handle next to the door. The door is then drawn tight by the lock nut operated by the outer handle. The door can thus be quickly opened and closed. No difficulty has been encountered in maintaining a tight-metal-to-metal joint at the edge of such doors so long as the diameter is kept within suitable limits.

Driving and Running Gear

The cylinders are of cast iron, poured in the railroad's own foundry. The cylinders on the 4-4-4 type locomotive are spaced on 7-ft. 1-in. centers and on the 4-6-4 type locomotives, on 7-ft. 5-in. centers. The steam pipes from the superheater headers to the cylinders, however, are of cast steel. The throttle valves are of the inside-connected dome type. The pistons are Z-section electric steel castings and are packed with three-section brass rings furnished by the Locomotive Finished Material Company. King type packing is applied on piston rods and valve stems, the piston-rod packing being of the tandem type. Crossheads are of the Dean type.

The steam distribution is controlled by 10-in. piston valves and Walschaert valve motion providing a maximum valve travel of 7 in. Cut-off is limited to 75 per cent. The reverse-gear cylinder is mounted under the boiler between the driving wheels and is controlled by



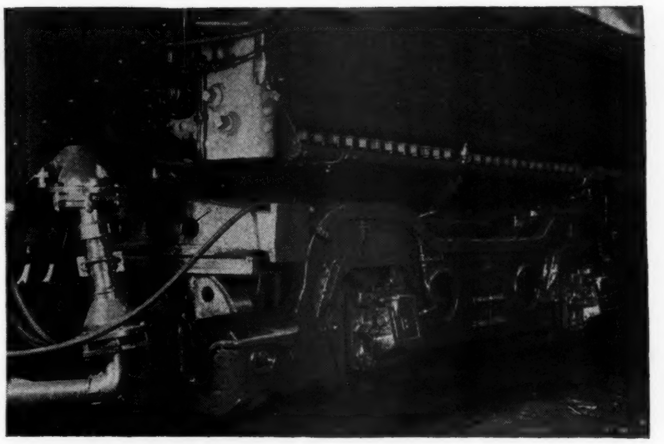
Elevation drawing of the Baltimore & Ohio

the Milner operating valve which is designed to effect a highly sensitive control of pressure in the reverse-gear cylinder and to prevent creeping. Both locomotives have main rods 10 ft. 6 in. long which connect to the second pair of drivers. Both main and side rods are chrome-vanadium steel.

The center of gravity of the J-1 locomotive is 5 ft. 7 in. above the rails and 5 ft. 9¼ in. on the V-2 locomotive. The trailing trucks on both locomotives are equipped with Franklin high-speed, high-pressure boosters capable of operating up to 35 m.p.h. before being cut out. They are fitted with limited cut-off and operate with high steam economy. The booster steam and exhaust piping is carried forward through the ash pan and between the frames. The booster exhaust is piped into the exhaust nozzle in the front end of the 4-4-4 type locomotive. In the 4-6-4 type, however, the exhaust is delivered through a flanged connection at the base of the stack inside the front-end to an annular passage cast around the stack and is discharged through annular openings at the top of the stack.

Both locomotives are built up on cast-steel frames braced with bolted cross-ties and provided with a cast-steel cradle at the rear end. All driving journals on the smaller locomotives are fitted with Grisco driving boxes having adjustable quarter bearings. On the six-coupled locomotive they are applied on the main journals only.

Both locomotives have been cross-balanced. The driving-wheel loads being relatively light and the cylinder diameters unusually small because of the high boiler pressure, the probem of counterbalancing to avoid excessive rail loads at high speeds presented no unusual difficulties. The reciprocating parts on one side of the four-coupled locomotive weigh less than 1,000 lb. The drivers are equalized with the trailing truck, the front truck forming the third point of support. The axles are carbon steel and the crank pins are nickel steel. Both axles and crank pins are hollow bored. The crank pins are lubricated with Spee-D fittings. Alemite fittings are applied at the important bearings in the motion work and also



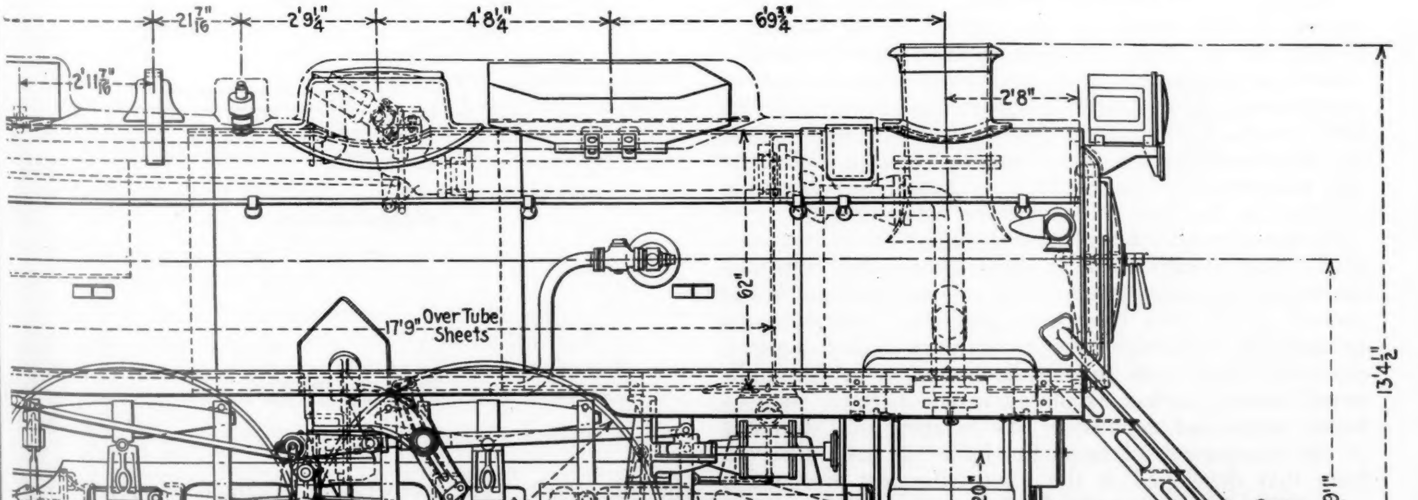
Rear corner view of four-wheel trailer truck

at all friction points on the spring and brake riggings.

The engine-truck and trailer frames are cast steel furnished by the General Steel Castings Corporation. All truck wheels are 36 in. in diameter. The engine truck has 6½-in. by 12-in. journals and the trailing truck, 7-in. by 13-in. journals.

In order to prevent the possibility of obstructions being rolled under and derailing the locomotive the pilot has been arranged to conceal the coupler when not in actual use. The front-end coupler pocket in the bumper casting has been enlarged so that the coupler may be rotated horizontally about its pin until it is entirely enclosed within the pocket. The coupler, on being swung out into operating position, is secured by a simple link-and-pin arrangement shown in one of the illustrations. When the coupler is not in use a hinged section of the pilot, cast in aluminum to reduce weight, is dropped down over the coupler pocket in the bumper beam so that the pilot presents unbroken surfaces up to the top of the bumper.

(*Continued on page 194*)



4-4-4 type, class J-1, locomotive "Lady Baltimore"

Heat Transmission in Locomotive Boilers

Part 1

By H. S. Vincent*

Relative value of heating surfaces in firebox, tubes and flues and in superheater as determined from a study of known test data

THE transfer of heat through the walls of steam boilers has been the subject of much study, and reasonably accurate formulas have been deduced by which the *total evaporation* of a given design of boiler may be determined.

2—The purpose of the study presented herewith is to demonstrate the relative effect of the various heat-transferring elements which constitute the locomotive boiler, viz., firebox, tubes and superheater. Data is presented to support the following conclusions;—

(a) the transfer of heat through the walls of the locomotive firebox is greater per unit of area than is contemplated in prevailing design data,

(b) the transfer of heat through the tubes and flues to the surrounding water is correspondingly less,

(c) the evaporative capacity of boilers with stayed fireboxes is limited by the evaporation of the firebox,

(d) the unit evaporative rate of firebox, tubes and superheater bears a definite relation to the ratio between grate area and the respective heating surfaces.

3—The most elaborate attempt to determine the relative heat absorption of firebox and tubes in a locomotive boiler, under similar operating conditions, was made by the late Prof. W. F. M. Goss,[1] in 1912, utilizing for the purpose two boilers of modern design, in which the shell compartment was isolated from the firebox. The water fed to each compartment was separately measured and a complete set of test data secured. This test was conducted at the works of the Lukens Steel Company, Coatesville, Pa., and is known as the Coatesville test.

4—The data resulting from this test was the basis of an elaborate set of boiler design ratios prepared by the late Francis J. Cole, then chief consulting engineer for the American Locomotive Company, and published by that company.[2] The Cole ratios have been generally accepted as the basis of locomotive boiler design.

5—As a result of the present study, the writer concludes that, though the Cole ratios give a close approximation of the total evaporation of the type of boiler current at the date they were published, caution must be used in applying them to modern boiler designs, especially those with tubular fireboxes, or where additional heating surface is placed in the firebox, such as water tubes and syphons. The relative heat transfer of the component parts of the boiler is very different from that developed in the Coatesville test and which was assumed by Cole to be fundamental.

6—In all of the early locomotive tests, the firebox temperature was recorded for one position only. In most cases the record does not clearly disclose the exact location of the pyrometer. Some writers on the subject have apparently assumed that the temperature is constant throughout the firebox.

7—The point of departure for the present study is the most recent tests of locomotives, conducted both at Altoona and by the University of Illinois. In these tests the firebox temperature was taken at two positions, one near the firebed, the other adjacent the rear tube sheet. The readings taken at these two positions prove that there is an abrupt drop in the temperature of the gases while passing from the firebed to the tube sheet. There is not yet sufficient evidence to prove that this is a straight line drop; however, as the final temperature is in all cases greater than half the initial temperature, it may be closely represented by a straight line connecting the two temperatures, plotted to a scale in which the distance between the two readings is equal to the average path of flame travel.

8—The method of determining the length of flame travel is indicated by Fig. 1. It is assumed to be the average distance between any part of the fuel bed and the tube sheet. The temperature gradient between firebed and tube sheet is represented by Fig. 2. As the actual temperature readings are taken at points very near the firebed and tube sheet, extrapolation to these positions may be relied on as reasonably accurate.

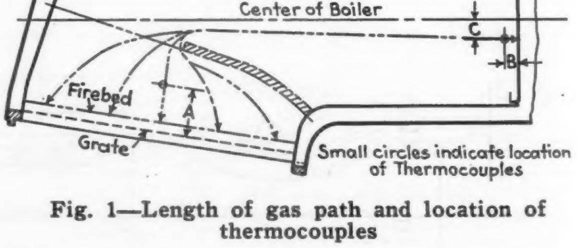


Fig. 1—Length of gas path and location of thermocouples

Loco. class	Location of Thermocouples A	B	C
M1a	22	6	9
K4s	22	7	9
I1s	22	7	9
60,000	22	6	9
1742	26	12	8
1742 syphon	26	12	8
E3sd	20	in tube and flue	
H8sb	20	in tube and flue	8

All dimensions are approximate and given in inches

9—The basis of all the calculations is the weight of mixed gases passing over the heating surfaces; therefore, the first step was to draw a "heat balance." This was calculated in accordance with the method originated by Lawford H. Fry and fully explained in his book, A Study of the Locomotive Boiler.[3] Having determined from the heat balance the available heat liberated at the grate and knowing the heat content of the gases enter-

* Formerly chief consulting engineer, Franklin Railway Supply Co.
[1] Tests of a Jacobs-Shupert Boiler, W. F. M. Goss, 1912.
[2] Bulletin No. 1017, January, 1914.

ing the tubes, we have, by difference, a measure of the heat transferred in the firebox by radiation and convection. The test records disclose the quantity of heat absorbed in evaporation, also that transferred over the superheating surfaces. Fry has shown that the heat lost by external radiation is approximately five per cent of that absorbed in evaporation. We can therefore, determine the heat transferred over the tubes and flues by difference.

10—A series of Tables, 1-9 and 10-18, is presented, covering 62 locomotive and boiler tests. For the sake of brevity, much of the calculated data involving the heat balance is omitted. In Tables 1-9, inclusive, the actual test data as taken from original records and that derived from the heat balance are shown. Tables 10-18, inclusive, indicate the calculated distribution of the heat liberated at the grate. A word of explanation is necessary in regard to columns 2a-6a, inclusive, of Tables 10-18. It is the practice in locomotive testing to take only one firebox temperature measurement for each complete test, regardless of length of time involved. Though every precaution is taken to insure uniform conditions; because of variations in air flow, fire thickness and fluctuations in rate of firing, the temperature varies considerably during a test. For this reason, a graph of temperature readings for a series of tests will show some scattering of results although in all cases the trend is evident.

11—As the whole argument in this case is based on firebox temperature, it was thought more accurate to draw first a smooth curve through the actual test positions for each series and use this in obtaining the temperature drop in the firebox. This precaution is not necessary for smokebox temperature, as readings are taken frequently throughout a test. The location of the thermocouples used in taking firebox temperatures is shown in Fig. 1. The source of the basic data where generally available, is indicated in the table headings.

12—Determination of the values shown in Tables 10-18, involve the specific heat of the gases of combustion. This is used in preparing Table 19, "Sensible Heat in Gases of Combustion." In the preparation of this table, the equations of Langen as given by L. S. Marks,[4] have been used. These equations were selected because the specific heat of water vapor given therein corresponds closely with the latest conclusion of Keenan[5] and other physicists. The mean specific heat of the mixed gases is given by the equation;—

$$C_p = 0.235 + 0.000017\,t \quad \text{(1)}$$

in which
C_p = mean specific heat at constant pressure between 0 deg. to t deg. F.
t = temperature of the gas, deg. F.

In calculating the heat imparted to the gases by combustion of the fuel, it is necessary to deduct the sensible heat at atmospheric temperature from the heat at gas temperature as read from the pyrometer, using equation (1), for both.

13—In further explanation of Tables 1-9 and 10-18, the contents of columns 1-13 and 1a-19a, are described in detail;—

Tables 1-9

Column 1: Original test numbers.

Column 2: Temperature recorded in laboratory by dry bulb thermometer.

Column 3: Temperature in smokebox, recorded at Altoona on two industrial type thermometers, record taken at ten minute intervals and averaged: At University of Illinois, temperature recorded by pyrometer.

Column 4: Temperature in firebox as read from thermocouple located near firebed as indicated in Fig. 1.

Column 5: Temperature in firebox as read from thermocouple located near tube sheet, position as indicated in Fig. 1.

Column 6: Weight of dry fuel fired per hour, per sq. ft. of grate surface, as recorded in test data.

Column 7: Boiler efficiency expressed as percentage of the heating value of the dry fuel fired.

Column 8: Fuel burned expressed as percentage of dry fuel fired. This is determined from the heat balance as constructed by the Fry method.

Column 9: Weight of mixed gases passing through firebox and tubes. This is the weight of dry gas per pound of fuel burned, as determined from smokebox analysis, plus the weight of water vapor produced by combustion of the hydrogen in one pound of the fuel; × column 6 × column 8.

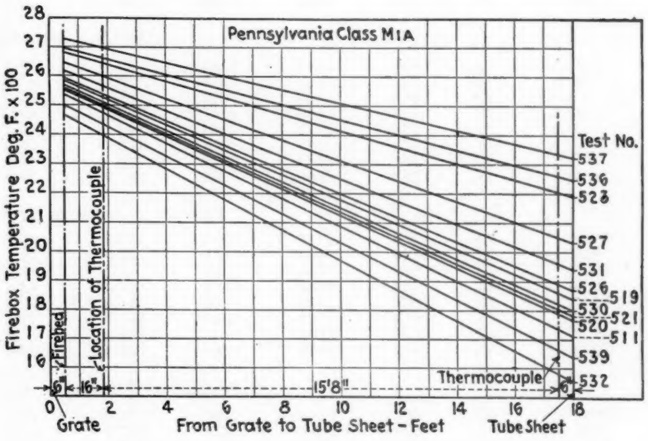


Fig. 2—Temperature gradient between firebed and flue sheet

Column 10: B.t.u. per sfg/hr. in dry fuel fired, = column 6 × calorific value per pound of dry fuel fired.

Column 11: B.t.u. per sfg/hr. available for absorption. This is the heat shown in Column 10, minus (a), heat in unburned fuel, (b), heat lost by formation of CO, and (c), latent heat of vaporization absorbed from firebed in burning the hydrogen in the fuel. (This latent heat is not available, as the temperature does not fall to the condensation level at any point in the gas path).

Column 12: B.t.u. per sfg/hr. available for absorption but lost in the smokebox gas, = column 9 × sensible heat above atmosphere of the gases at smokebox temperature.

Column 13: B.t.u. per sfg/hr. utilized in evaporation and external radiation, or the heat in the dry fuel fired which is absorbed by the boiler heating surfaces, = column 6, × column 7 × calorific value per pound of dry fuel fired × 1.05. Column 13 = column 11 — column 12.

Tables 10-18

Column 1a: Same as column 1, Tables 1-9.

Column 2a: Temperature in firebox near firebed, as read from curve, Fig. 2, at location of thermocouple Fig. 1.

Column 3a: Temperature in firebox near fluesheet, as read from curve, Fig. 2, at location of thermocouple Fig. 1.

Column 4a: Calculated temperature of gases at surface of firebed, obtained by extrapolation of temperature gradient Fig. 2.

[3] Simmons-Boardman Publishing Company.
[4] Mechanical Engineers' Hand Book, L. S. Marks.
[5] Steam Tables and Mollier Diagram, Keenan.

Tables 1-9—Test Data from Original Sources

1	2	3	4	5	6	7	8	9	10	11	12	13
	Temperature From Test								1000 B.t.u. per S.F.G./Hr.			
Test Numbers (Original)	Laboratory, Fahr.	Smokebox, Fahr.	Firebox Near Firebed, Fahr.	Firebox Near Tube Sheet, Fahr.	Dry Fuel Fired, Lb. per S.F.G./Hr.	Per Cent of Fuel Fired Utilized in Evaporation	Fuel Burned as Per Cent of Fuel Fired	Mixed Gas, Lb. per S.F.G./Hr.	In Dry Fuel Fired, B.t.u.	Available for Absorption, B.t.u.	In Smokebox Gas B.t.u.	Utilized in Evaporation and Radiation, B.t.u.
TABLE 1—Pennsylvania, Class M1a												
532	76	541	2278	1582	67.3	59.1	76.8	899.5	930.5	680.6	102.8	577.8
539	73	545	2588	1741	80.5	56.1	73.0	1057.0	1116.0	780.0	122.7	657.3
511	90	578	2495	1631	94.4	59.0	76.2	1202.0	1305.0	954.3	144.4	809.9
520	84	571	2577	1563	105.4	57.6	73.9	1217.0	1457.0	1027.9	146.0	881.9
521	82	568	2428	1660	108.8	55.4	70.8	1215.0	1504.0	1021.1	145.2	875.9
530	73	606	2717	2013	112.8	56.7	74.2	1380.0	1559.0	1109.6	181.5	928.1
519	88	590	2067	1762	122.0	55.2	71.1	1418.0	1686.0	1153.8	175.7	978.1
526	87	594	2681	2239	128.1	53.8	68.8	1313.0	1771.0	1165.6	164.1	1001.5
531	76	629	2726	1931	146.9	50.0	66.9	1558.0	2031.0	1279.5	212.7	1066.8
527	84	647	2369	1663	174.6	49.9	66.5	1855.0	2415.0	1524.5	258.5	1266.0
523	82	672	2577	2203	231.2	44.7	59.7	2208.0	3195.0	1821.5	322.5	1499.0
536	66	701	2726	2391	260.9	43.9	58.3	2016.0	3610.0	1982.0	317.0	1665.0
537	70	713	2666	2218	327.4	37.3	50.3	2250.0	4525.0	2130.0	359.0	1771.0
TABLE 2—Pennsylvania, Class K4s												
438-A	84	580	2447	1743	49.4	76.0	97.6	780.5	693.9	648.9	95.4	553.5
434-A	90	646	2369	1756	78.4	67.0	90.2	1205.0	1104.0	943.6	165.6	778.0
435-A	78	664	2335	2020	86.8	67.2	88.4	1160.0	1222.0	1031.4	168.4	863.0
436-A	80	714	2650	2003	109.2	67.2	89.4	1406.0	1538.0	1307.1	221.1	1086.0
437-A	85	761	2771	1984	140.6	60.9	81.8	1593.0	1980.0	1535.2	268.2	1267.0
441-A	74	725	2785	2082	148.1	58.1	77.9	1650.0	2080.0	1535.5	266.5	1269.0
440-A	92	747	2711	2278	184.2	52.5	71.1	1635.0	2583.5	1689.3	266.8	1422.5
439-A	91	769	2666	2260	185.7	51.6	69.5	1594.0	2609.0	1682.0	269.5	1412.5
TABLE 3—Baldwin Locomotive Works, No. 60,000												
7912	72	519	2415	1980	34.7	69.0	89.6	575.7	475.8	407.7	63.0	344.7
7918	72	546	2534	2171	44.0	71.5	91.4	670.0	603.5	531.1	78.1	453.0
7915	72	567	2746	2268	62.1	66.2	84.9	835.0	851.5	693.4	101.5	591.9
7924	64	603	2694	2156	75.4	63.3	81.1	906.0	1034.0	807.8	120.3	687.5
7907	71	600	2798	2188	87.0	62.2	79.6	1044.0	1193.0	915.3	136.3	779.0
7925	65	638	2733	2244	112.2	57.5	76.1	1260.0	1538.0	1107.2	178.2	929.0
7927	65	645	2798	2347	135.2	53.3	68.8	1296.0	1854.0	1223.5	185.5	1038.0
7923	82	637	2826	2288	143.4	50.0	64.9	1306.5	1965.0	1211.1	179.1	1032.0
TABLE 4—Pennsylvania, Class I1s, Bulletin No. 32												
5919	63	605	2560	1780	68.4	65.0	82.0	780.0	940.3	744.0	104.0	640.0
5933	64	629	2648	1926	127.1	54.0	69.9	1328.5	1751.0	1178.2	185.2	993.0
6123	74	643	2892	2392	212.1	36.0	49.9	1331.5	2989.0	1318.0	187.0	1131.0
TABLE 5—Illinois Central, No. 1742, Bulletin No. 220, University of Illinois												
2703	54	504	2017	1580	33.2	68.8	88.0	455.0	426.8	358.4	50.1	308.3
2701	61	542	2140	1760	47.9	71.7	92.3	628.2	602.6	528.0	74.2	453.8
2707	84	516	2074	1817	49.9	69.5	87.4	620.0	627.2	522.8	65.6	457.2
2708	82	564	2182	1893	77.9	65.6	84.4	1023.2	1006.0	814.0	121.0	693.0
2710	79	584	2226	1920	94.5	67.3	86.8	1054.0	1173.8	960.4	131.2	829.2
2713	86	575	2212	1905	95.0	66.7	83.8	993.5	1160.0	932.5	119.5	813.0
TABLE 6—Illinois Central, No. 1742 with Syphon, Bulletin No. 220, University of Illinois												
2724	88	486	1708	1313	30.9	77.8	96.4	438.0	381.6	354.4	42.7	311.7
2725	88	515	1865	1400	44.4	76.3	94.6	576.0	561.5	510.3	60.3	450.0
2729	80	535	1776	1328	45.1	75.5	96.2	672.0	566.1	524.0	75.2	448.8
2723	64	575	2071	1477	69.8	73.3	94.4	926.2	882.0	795.5	116.4	679.1
2726	89	575	2114	1552	85.6	70.9	90.1	977.0	1015.0	873.2	117.0	756.2
2721	64	602	2184	1518	85.9	70.5	90.8	1064.0	1088.0	947.1	141.1	806.0
TABLE 7—Pennsylvania, Class E3sd, Bulletin No. 11												
3136	61	673	1962	1775	44.8	69.7	91.0	599.1	653.7	569.4	90.8	478.6
3137	56	691	2122	1825	53.8	64.2	85.5	695.9	784.2	638.2	109.4	528.8
3128	67	718	1922	1740	75.1	61.1	80.8	828.5	1095.2	836.8	133.8	703.0
3125	55	728	2197	1760	89.9	58.8	81.7	1210.0	1282.1	993.2	202.0	791.2
3127	64	743	2063	1660	102.6	47.4	69.8	928.5	1497.0	902.2	156.9	745.3
3109	58	730	2322	1875	104.3	54.3	82.0	1094.0	1505.7	1041.0	182.6	858.4
TABLE 8—Pennsylvania, Class H8sb, Bulletin No. 10												
3207	64	448	1924	1320	17.7	80.4	97.6	286.0	259.1	245.7	26.8	218.9
3209	56	522	2158	1695	36.7	69.2	84.9	409.2	538.6	438.2	46.7	391.5
3211	64	573	2360	1835	53.0	61.6	76.4	518.5	776.7	567.1	64.9	502.2
3213	67	624	2390	1820	73.1	57.6	74.3	635.9	1072.5	735.5	87.3	648.2
3224	55	662	2340	2060	88.0	60.6	77.8	858.0	1173.0	875.3	128.8	746.5
3217	67	646	2405	1925	113.3	48.4	66.5	838.0	1568.1	917.8	119.8	798.0
TABLE 9—Coatesville Test, Radial Stayed Boiler												
A107R	51	602	....	....	29.6	60.2	90.5	678.2	409.0	350.8	92.0	258.8
A108R	62	499	....	....	24.7	68.7	89.2	585.0	365.0	325.7	62.5	263.2
A109R	57	572	....	....	41.6	64.7	83.8	641.5	624.0	504.6	81.0	423.6
A110R	66	568	....	....	48.7	60.5	84.2	900.0	673.7	539.1	111.1	428.0
A111R	54	618	....	....	73.1	61.1	91.0	1510.0	977.5	838.0	210.0	628.0
A112R	56	615	....	....	71.1	60.1	83.5	1146.0	959.0	764.8	157.9	606.9

Column 5a: Calculated temperature of gases at tube entrance, obtained by extrapolation of temperature gradient Fig. 2.

Column 6a: Mean gas temperature between firebed and tube entrance. Average of columns 4a and 5a.

Column 7a: B.t.u. per sfg/hr. in gas at tube entrance, = column 9 × sensible heat above atmosphere, of gas at temperature column 5a.

Column 8a: B.t.u. per sfg/hr. traversed across firebox heating surface including arch tubes and syphons, = column 11 — column 7a.

Column 9a: B.t.u. per sfg/hr. transferred across tube and flue heating surfaces, = column 13 — (column 8a + 10a).

Column 10a: B.t.u. per sfg/hr. transferred across superheating surface, from test record.

Column 11a: Percentage of total heat transferred across firebox heating surface, = column 8a / column 13.

Column 12a: Percentage of total heat transferred

Tables 10-18—Distribution of Heat Liberated in Firebox

1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	14a	15a	16a	17a	18a	19a
	Firebox Temperature Calculated						1000 B.t.u. per S.F.G./Hr. Transferred Over			Per Cent of Total Heat Transferred Over			Equiv. Evaporation per Hour per Sq. Ft. of Heating Surface			Coefficient of Heat Transfer Average		
Test Numbers	Gases Above Firebed	Gases Near Tube Sheet	Gases at Firebed from Fig. 2	Gases at Tube Sheet from Fig. 2	Mean Gas	1000 B.t.u. per S.F.G./Hr. in Gases at Tube Sheet	Firebox	Tubes and Flues	Superheater	Firebox	Tubes and Flues	Superheater	Wf. Firebox	Wt. Tubes and Flues	Ws. Superheater	Kf. Firebox	Kt. Tubes and Flues	Ks. Superheater
	Fahr.	Fahr.	Fahr.	Fahr.	Fahr.	B.t.u.	B.t.u.	B.t.u.	B.t.u.	Per Cent	Per Cent	Per Cent	Pounds	Pounds	Pounds	B.t.u.	B.t.u.	B.t.u.
TABLE 10—Pennsylvania, Class M1a																		
532	2398	1582	2466	1556	2011	349.2	331.4	193.7	52.7	57.4	33.5	9.1	57.0	3.08	2.33	36.2	6.64	6.01
539	2432	1662	2500	1639	2069	437.2	342.8	256.1	58.4	52.2	39.0	8.8	58.9	4.07	2.58	36.1	8.29	6.17
511	2472	1738	2535	1712	2123	518.0	436.3	288.5	85.1	54.0	35.6	10.4	75.1	4.59	3.76	44.6	8.37	8.17
520	2492	1790	2552	1769	2160	547.0	480.9	303.0	98.0	54.6	34.4	11.0	82.7	4.82	4.33	48.0	8.68	9.33
521	2500	1808	2559	1784	2171	551.5	469.6	308.9	97.4	53.6	35.3	11.1	80.8	4.91	4.30	46.6	8.83	9.28
530	2510	1824	2570	1803	2186	637.3	472.3	348.4	107.6	50.9	37.6	11.5	81.3	5.54	4.76	46.8	9.18	9.36
519	2527	1862	2584	1840	2212	666.0	487.8	378.8	111.5	49.8	38.7	11.5	83.8	6.03	4.93	47.3	10.16	9.90
526	2539	1890	2593	1870	2231	629.0	536.6	356.4	108.5	53.6	35.7	10.7	92.3	5.68	4.79	51.5	9.30	9.17
531	2565	1960	2617	1940	2278	783.5	496.0	440.4	130.4	47.0	41.3	11.7	85.3	7.01	5.76	46.4	10.50	10.12
527	2598	2050	2644	2031	2337	979.0	545.5	560.0	160.5	43.1	44.2	12.7	93.8	8.91	7.10	49.5	12.50	11.77
523	2643	2203	2680	2190	2435	1273.0	548.5	803.0	147.5	36.6	53.5	9.9	94.4	12.77	6.52	47.4	16.30	9.73
536	2660	2260	2693	2247	2470	1206.0	776.0	657.8	231.2	46.6	39.5	13.9	133.4	10.46	10.22	65.9	12.62	14.29
537	2695	2333	2727	2322	2524	1396.0	734.0	787.8	249.2	41.4	44.5	14.1	126.1	12.53	11.02	60.7	14.53	14.66
TABLE 11—Pennsylvania, Class K4s																		
438A	2212	1654	2273	1632	1953	319.1	329.8	184.3	39.4	59.6	33.3	7.1	74.0	3.38	3.04	48.2	6.16	6.08
434A	2444	1886	2505	1862	2184	572.5	371.1	342.8	64.1	47.7	44.0	8.3	83.0	6.29	4.91	47.3	9.22	7.90
435A	2498	1943	2556	1922	2239	576.0	455.4	332.3	75.3	52.8	38.5	8.7	102.2	6.11	5.77	56.2	8.52	8.86
436A	2610	2063	2669	2042	2356	747.0	560.1	424.1	101.8	51.6	39.1	9.3	125.5	7.79	7.81	65.1	9.74	10.67
437A	2707	2181	2764	2160	2462	902.5	632.7	514.1	120.2	49.9	40.6	9.5	141.8	9.45	9.22	69.7	10.76	11.36
441A	2720	2202	2776	2182	2479	950.0	585.5	557.1	126.4	46.1	43.9	10.0	131.2	10.24	9.68	64.0	12.00	12.45
440A	2756	2246	2810	2223	2517	955.5	733.8	545.6	143.1	51.6	38.3	10.1	164.4	10.02	10.97	78.8	11.30	13.52
439A	2757	2247	2811	2224	2518	932.5	749.5	521.2	141.8	53.1	36.9	10.0	170.1	9.58	10.87	80.4	10.60	13.05
TABLE 12—Baldwin Locomotive Works, No. 60,000																		
7912	2420	1980	2461	1963	2212	293.0	114.7	206.9	23.1	33.3	60.0	6.7	12.0	3.78	1.28	6.91	7.79	2.85
7918	2550	2060	2598	2042	2320	357.1	174.0	238.9	40.1	38.4	52.7	8.9	18.2	4.37	2.22	9.87	7.98	4.50
7915	2690	2174	2740	2156	2448	474.1	219.3	314.1	58.5	37.0	53.1	9.9	23.0	5.75	3.24	11.63	9.53	5.99
7924	2750	2225	2800	2205	2503	530.0	277.8	337.5	72.2	40.4	49.1	10.5	29.1	6.18	4.00	14.36	9.26	6.64
7907	2775	2256	2823	2238	2531	620.0	295.3	401.8	81.9	37.9	51.6	10.5	31.0	7.35	4.54	15.05	10.95	7.51
7925	2820	2320	2868	2302	2585	775.4	331.8	489.8	107.4	35.7	52.7	11.6	34.8	8.96	5.95	16.50	12.22	8.99
7927	2840	2350	2888	2331	2610	809.9	413.6	503.4	121.0	39.8	48.5	11.7	43.4	9.22	6.71	20.35	12.28	9.86
7923	2845	2358	2891	2340	2616	814.0	397.1	509.5	125.4	38.5	49.4	12.1	41.7	9.33	6.95	19.50	12.53	10.41
TABLE 13—Pennsylvania, Class I1s, Bulletin No. 32																		
5919	2446	1850	2510	1825	2168	367.0	377.0	203.7	59.3	58.9	31.8	9.3	90.3	3.09	2.21	52.2	5.08	4.06
5933	2690	2155	2748	2133	2441	748.0	430.2	461.4	101.4	43.4	46.4	10.2	103.1	7.02	3.77	51.6	9.74	5.89
6123	2880	2355	2936	2333	2635	830.0	488.0	526.3	116.7	43.2	46.5	10.3	116.9	8.01	4.34	53.3	10.13	6.01
TABLE 14—Illinois Central, No. 1742, Bulletin No. 220, University of Illinois																		
2703	1990	1598	2050	1545	1798	177.7	180.7	98.4	29.2	58.6	31.9	9.5	46.8	1.77	2.46	33.6	3.87	6.25
2701	2080	1765	2127	1722	1925	277.0	251.0	162.2	40.6	55.3	35.7	9.0	65.0	2.92	3.88	42.9	5.32	7.17
2707	2109	1784	2157	1742	1950	273.1	249.7	164.3	43.2	54.6	35.9	9.5	64.6	2.95	3.65	42.0	5.65	7.96
2708	2174	1906	2216	1870	2043	490.0	324.0	295.1	73.9	46.7	42.6	10.7	83.9	5.31	6.23	51.4	8.67	11.56
2710	2192	1915	2238	1878	2058	509.0	451.4	278.7	99.1	54.4	33.6	12.0	117.0	5.01	8.36	71.0	7.86	15.25
2713	2193	1915	2238	1878	2058	478.0	454.5	262.1	96.4	55.9	32.2	11.9	117.7	4.72	8.14	71.5	7.52	15.01
TABLE 15—Illinois Central, No. 1742, with Syphons, Bulletin No. 220, University of Illinois																		
2724	1784	1312	1858	1250	1554	131.2	223.2	63.9	24.6	71.6	20.5	7.9	47.9	1.15	2.07	41.6	3.22	6.91
2725	1862	1360	1938	1294	1616	179.4	330.9	78.2	40.9	73.5	17.4	9.1	71.1	1.41	3.45	58.6	3.52	10.50
2729	1866	1363	1942	1298	1620	211.2	312.8	93.2	42.8	69.6	20.8	9.6	67.1	1.68	3.61	55.1	3.98	10.30
2723	2003	1450	2087	1374	1731	314.5	481.0	119.2	78.9	70.8	17.6	11.6	103.2	2.14	6.66	77.9	4.45	16.84
2726	2090	1508	2182	1431	1807	341.1	532.1	133.6	90.5	70.4	17.7	11.9	113.2	2.40	7.64	81.7	4.82	18.68
2721	2091	1509	2183	1432	1808	378.1	569.0	140.4	96.6	70.6	17.4	12.0	122.1	2.53	8.15	87.2	4.82	19.05
TABLE 16—Pennsylvania, Class E3sd, Bulletin No. 11																		
3136	1930	1790	1958	1774	1866	273.0	296.4	141.8	40.4	61.9	29.6	8.5	88.7	4.14	5.06	61.3	6.09	8.13
3137	2000	1810	2034	1789	1912	321.0	317.2	167.3	44.3	60.0	31.6	8.4	95.0	4.88	5.55	63.6	6.98	8.60
3128	2125	1840	2179	1808	1994	384.4	452.4	185.6	65.0	64.4	26.4	9.2	135.5	5.42	8.15	86.3	7.41	12.25
3125	2200	1830	2269	1789	2029	558.5	434.7	281.3	75.2	55.0	35.5	9.5	130.2	8.22	9.42	81.0	11.22	14.16
3127	2240	1780	2325	1729	2027	409.8	492.4	181.2	71.7	66.1	24.3	9.6	147.5	5.29	8.98	91.9	7.28	13.60
3109	2245	1770	2334	1716	2025	480.0	561.0	225.2	72.2	65.4	26.2	8.4	168.0	6.58	9.04	104.7	8.92	13.13
TABLE 17—Pennsylvania, Class H8sb, Bulletin No. 10																		
3207	1870	1320	1964	1264	1614	88.2	156.5	52.9	9.5	71.5	24.2	4.3	44.7	1.01	0.84	37.3	3.43	3.19
3209	2150	1640	2238	1588	1913	164.7	273.5	96.2	21.8	69.8	24.6	5.6	78.2	1.84	1.92	52.3	3.87	4.39
3211	2270	1790	2352	1742	2047	231.0	336.1	133.1	33.0	66.9	26.5	6.6	96.2	2.54	2.90	59.1	4.44	5.50
3213	2370	1910	2449	1864	2157	305.9	429.6	176.6	42.0	66.3	27.2	6.5	122.8	3.38	3.69	71.0	5.11	5.95
3224	2410	1970	2486	1927	2207	431.7	443.6	246.6	56.3	59.5	33.0	7.5	126.8	4.71	4.95	71.2	6.57	7.44
3217	2440	2035	2510	1997	2254	436.0	481.8	252.9	63.3	60.4	31.7	7.9	137.7	4.83	5.56	75.3	6.69	8.33
TABLE 18—Coatesville Test, Radial Stayed Boiler																		
A107R	....	....	1971	1331	1651	224.1	126.7	132.2	....	49.0	51.0	...	34.9	2.74	....	28.3	5.75	....
A108R	....	....	2112	1464	1788	213.8	111.9	151.2	....	42.6	57.4	...	30.8	3.12	....	22.6	7.60	....
A109R	....	....	2828	2170	2499	369.0	135.6	288.1	....	32.0	68.0	...	37.4	5.95	....	18.1	8.73	....
A110R	....	....	2249	1613	1931	366.4	172.7	256.0	....	40.3	59.7	...	47.6	5.28	....	31.6	10.04	....
A111R	....	....	2099	1626	1863	627.6	210.4	416.4	....	33.6	66.4	...	58.0	8.61	....	40.3	14.81	....
A112R	....	....	2460	1911	2186	571.6	193.2	412.8	....	31.9	68.1	...	53.3	8.54	....	30.3	12.67	....

Table 19—Sensible Heat in Gases of Combustion in B. t. u. per Pound of Gas at Various Temperatures, Degrees F

	0°	100°	200°	300°	400°	500°	600°	700°
0°	...	23.7	47.6	72.0	97.2	121.7	147.2	172.7
10°	2.3	26.1	50.1	74.5	99.4	124.2	149.7	175.3
20°	4.7	28.4	52.5	77.0	101.7	126.8	152.2	177.9
30°	7.0	30.8	55.0	79.5	104.2	129.4	154.7	180.6
40°	9.4	33.2	57.4	81.9	106.7	132.0	157.2	183.2
50°	11.8	35.6	59.8	84.4	109.2	134.4	159.9	185.7
60°	14.2	38.0	62.2	86.8	111.7	136.9	162.6	188.2
70°	16.5	40.4	64.7	89.3	114.2	139.4	165.1	190.8
80°	18.9	42.8	67.2	91.7	116.8	142.0	167.6	193.4
90°	21.3	45.2	69.6	94.2	119.3	144.6	170.2	196.0

	800°	900°	1000°	1100°	1200°	1300°	1400°	1500°
0°	198.6	225.2	252.0	279.0	306.5	334.0	362.0	390.5
10°	201.2	227.8	254.7	281.8	309.3	336.8	364.8	393.3
20°	203.9	230.5	257.4	284.6	312.1	339.6	367.6	396.1
30°	206.2	233.2	260.1	287.4	314.9	342.4	370.4	398.9
40°	208.6	236.0	262.8	290.2	317.7	345.2	373.2	401.7
50°	211.6	238.6	265.5	292.9	320.4	348.0	376.0	404.5
60°	214.7	241.2	268.3	295.6	323.0	350.8	378.8	407.3
70°	217.4	243.8	271.0	298.3	325.7	353.6	381.6	410.2
80°	220.1	246.4	273.7	301.0	328.4	356.4	384.4	413.1
90°	222.8	249.0	276.3	303.7	331.2	359.5	387.5	416.2

	1600°	1700°	1800°	1900°	2000°	2100°	2200°	2300°
0°	419.4	448.0	478.0	508.0	538.0	568.2	599.0	630.0
10°	422.4	451.0	481.0	511.0	541.0	571.0	602.1	633.1
20°	425.4	454.0	484.0	514.0	544.0	574.0	605.2	636.2
30°	428.4	457.0	487.0	517.0	547.0	577.0	608.3	639.3
40°	431.3	460.0	490.0	520.0	550.0	580.0	611.4	642.5
50°	434.3	463.0	493.0	522.9	553.0	583.2	614.6	645.7
60°	437.0	466.0	496.0	525.8	556.0	586.4	617.8	648.9
70°	439.8	469.0	499.0	528.7	559.0	589.6	621.0	652.0
80°	442.6	472.0	502.0	531.8	562.0	592.9	624.2	655.2
90°	445.4	475.2	504.8	534.5	565.0	596.0	627.2	658.5

	2400°	2500°	2600°	2700°	2800°	2900°	3000°	3100°
0°	662.0	694.0	726.0	758.0	791.0	824.5	858.0	892.0
10°	665.2	697.2	729.2	761.3	794.4	827.8	861.4	895.4
20°	668.4	700.4	732.4	764.6	797.7	831.1	864.8	898.8
30°	671.6	703.6	735.6	767.9	801.1	834.4	868.2	902.2
40°	674.8	706.8	738.8	771.2	804.4	837.7	871.6	905.6
50°	678.0	710.1	742.1	774.6	807.8	841.0	875.0	909.1
60°	681.3	713.4	745.4	778.0	811.2	844.4	878.4	912.6
70°	684.6	716.7	748.8	781.4	814.6	847.8	881.8	916.1
80°	687.9	720.0	752.2	784.7	818.0	851.4	885.2	919.6
90°	691.2	723.0	755.2	788.0	821.5	854.5	888.5	923.0

Mean specific heat is given by equation $Cp = 0.235 + 0.000017t$, where t is the gas temperature in degrees fahr. Interpolate for intermediate temperatures.

across tube and flue heating surfaces, = column 9a / column 13.

Column 13a: Percentage of total heat transferred across superheating surfaces, = column 10a / column 13.

Column 14a: Equivalent evaporation per hour per sq. ft. of firebox heating surface;—

$$wf = \frac{\text{column 8a}}{R \times 970 \times 1.05} \qquad \text{.......... (2)}$$

Column 15a: Equivalent evaporation per hour per sq. ft. of tube and flue heating surface;—

$$wt = \frac{\text{column 9a}}{R_1 \times 970 \times 1.05} \qquad \text{.......... (3)}$$

Column 16a: Equivalent evaporation per hour per sq. ft. of superheating surface*;—

* Wherever the term "equivalent evaporation of superheater" occurs in this article its meaning is "heat transferred over superheater in terms of equivalent evaporation.

$$ws = \frac{\text{column 10a}}{R_2 \times 970} \qquad \text{.......... (4)}$$

Column 17a: B.t.u. per hour, transferred across one sq. ft. of firebox heating surface per degree temperature difference between mean gas and water;—

$$kf = \frac{\text{column 8a}}{R \times (a + b) / 2} \qquad \text{.......... (5)}$$

Column 18a: B.t.u. per hour, transferred across one sq. ft. of tube and flue heating surface, per degree temperature difference between mean gas and water;—

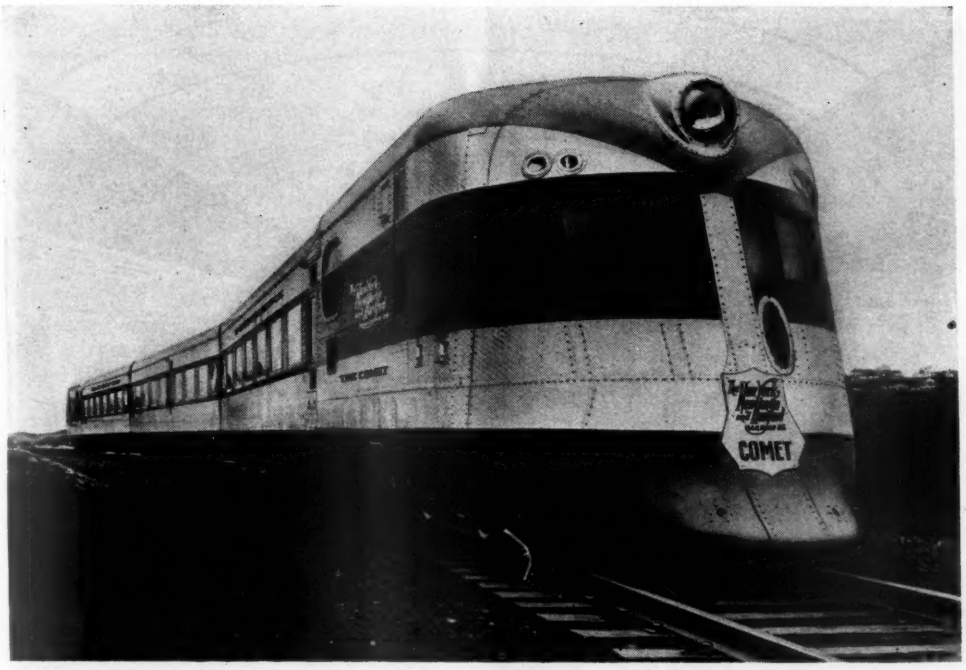
$$kt = \frac{\text{column 9a}}{R_1 \times (b - c)/(\log_e b/c)} \qquad \text{.......... (6)}$$

Column 19a: B.t.u. per hour, transferred across one sq. ft. of superheating surface, per degree temperature

(*Continued on page 194*)

Table 20—Characteristics of Boilers for Which Test Data Are Shown

Railroad or owner	Pennsylvania	Pennsylvania	Pennsylvania	Bald. Loco. Wks.	Ill. Central	Ill. Central	Pennsylvania	Pennsylvania	J. S. Firebox Co.
Location of test plant	Altoona	Altoona	Altoona	Altoona	Univ. of Ill.	Univ. of Ill.	Altoona	Altoona	Coatesville, Pa.
Class or number of locomotive	M1a	K4s	I1s	60,000	1742	1742	E3sd	H8sb	....
Date first built	1923	1914	1922	1926	1915	1915	1908	1908	1912
Type of boiler	Ext. wagon top	Ext. wagon top	Ext. wagon top	Wagon top	Straight top	Straight top	Ext. wagon top	Ext. wagon top	Ext. wagon top
Steam pressure—lb. per sq. in.	250	205	250	350	180	180	205	205	215
Diam. at first course, outside—in.	84½	76½	84½	84	82	82	67	75½	70
Diam. at dome course, outside—in.	96	91	93	94	85	85	71⅝	85	83⅞
Firebox length at grate—in.	126	125½	126	138¼	120⅝	120⅝	111	109⅞	109 11/16
Firebox width at grate—in.	79⅞	80	79⅞	86	84	84	72	72	76¼
Grate area—sq. ft.	69.9	69.8	69.9	82.5	70.3	70.3	54.7	55.3	58.07
Combustion chamber length—in.	98	36	40	61	None	None	None	None	None
Fire-brick arch	With	With	With	With	With	With	With	With	None
Syphon	None	None	None	None	None	With	None	None	None
Firebox type	Belpaire	Belpaire	Belpaire	Water-tube	Radial stay	Radial stay	Belpaire	Belpaire	Radial stay
Number of fire tubes	120	237	114	206	262	262	170	265	290
Diam. of tubes—in.	2¼	2¼	2¼	2¼	2	2	2	2	2¼
Number of flues	170	40	200	50	36	36	24	36	....
Diam. of flues—in.	3½	5½	3¼	5½	5⅜	5⅜	5⅜	5⅜	....
Length of tubes and flues—ft. and in.	19–0	19–0	19–0	23–0	20–6	20–6	15–0	15–0	18–2
Spacing of tubes and flues—ft. and in.	⅝	⅝	⅝	¾	⅞	⅞	⅝	¾	1
Type of superheater	E	A	E	A	A	A	A	A	....
Net area through tubes and flues—sq. in.	1,417	1,314	1,315	1,345	1,092	1,092	725.4	1,132	911
Net flue area—per cent of total	73.4	43.3	72.5	51.8	43.4	43.4	43.6	43.6	....
Firebox volumn—cu. ft.	582	427	364	683	346	346	200	199	....
Heating surface firebox inc. comb. chamber—sq. ft.	370	277.8	258	745	235	235	153.8	152.6	206.7
Heating surface arch tubes or syphons—sq. ft.	29	29	29	27	31.6	86.6	25.6	26.4	....
Total firebox heating surface—sq. ft	399	306.8	287	772	266.6	321.6	179.4	189	206.7
Heating surface tubes—sq. ft.	1,342	2,643.7	1,276	2,775	2,799	2,799	1,335	2,081	2,759
Heating surface flues—sq. ft.	2,961	1,090.7	3,236	1,645	1,034	1,034	507	760	....
Heating surface tubes and flues—sq. ft.	4,303	3,734.4	4,512	4,420	3,833	3,833	1,842	2,841	2,759
Heating surface superheater—sq. ft.	1.630	940.	1,940	1,535	860	860	450	649	....
Combined heating surface—sq. ft.	6,332	4,981.2	6,739	6.727	4,959.6	5,014.6	2,471.4	3,679	2,965.7
Firebox, per cent comb. heat. surface	6.3	6.2	4.3	11.5	5.4	6.4	7.3	5.1	7.0
Tubes & flues, per cent comb. heat surface	68.0	75.0	67.0	65.7	77.3	76.5	74.6	77.3	93.0
Superheater, per cent comb. heat. surface	25.7	18.9	28.8	22.8	17.3	17.1	18.2	17.6	....
R—Ratio firebox heating surface to grate area	5.71	4.38	4.1	9.36	3.79	4.57	3.28	3.43	3.56
R_1—Ratio tube and flue heating surface to grate area	61.7	53.4	64.5	53.6	54.5	54.5	33.6	51.4	47.5
R_2—Ratio superheating surface to grate area	23.33	13.44	27.7	18.61	12.22	12.22	8.23	11.73	....
Per cent of firebox heat. surface in comb. chamber	40	18	22	31.3	....	....	....	....	....



New Haven "Comet" Embodies Unusual Features of Design

AT 7 a.m. on April 27 the latest addition to the group of America's high-speed streamline trains, the New Haven's "Comet," left Akron, Ohio, where it was built at the plant of the Goodyear-Zeppelin Corporation, for New Haven, Conn., arriving there at 10:51 p.m. the same day. The following Monday, April 29, the Comet made a run from New Haven to Boston, during which it covered 156.8 miles in 143 min. and attained a speed of 110.29 m.p.h.

Unlike the trains which have preceded it in the light-weight field this train is built with a power plant in each end. This design was adopted because of the service for which it was built—to furnish rapid, frequent service between two points (Boston, Mass., and Providence, R. I.), in a territory of dense traffic where turn-arounds are not possible. For this reason all of the space not used for the power plants is arranged to accommodate only coach passengers, the journey between these two points involving less than three-quarters of an hour. After a series of exhibition trips on which the Comet will be shown to the public at various points in New England, it is scheduled to go into regular service between the above-mentioned points on June 5, making five round trips over the 44-mile territory each day except Sunday.

General Description

The Comet consists of three body sections, articulated and carried on four trucks. It is powered with two Westinghouse six-cylinder, 400-hp. Diesel engines, one on each end of the train. Each of the two end body units consists of an engine room and a passenger compartment with seats for 48 persons, and the center unit contains additional passenger space in the form of a 36-passenger section and a smoking compartment seating 28 persons. The train is constructed principally of aluminum and high-strength steels and the exterior, which is built entirely of aluminum, is strikingly finished in a color scheme in which the natural aluminum with a whorled finish provides a contrast with the gray of the roof and two shades of blue enamel, a light blue at the window panel level and a dark blue around the bottom. The color arrangement was worked out in collaboration with the New Haven by the Sherwin-Williams Company which furnished the finishing materials for both exterior and interior. Because of the type of service for which the Comet was built no effort was made to "decorate" the interior. The color scheme and furn-

Facts About the New Haven "Comet"

Designer and builder	Goodyear Zeppelin Corp.
Built at	Akron, Ohio
Powered by	Two Westinghouse 400-hp. Diesel engines
Electrical equipment built by	Westinghouse Elec. & Mfg. Co.
Air conditioned by	Westinghouse Elec. & Mfg. Co.
Heating system furnished by	Vapor Car Heating Co.
Air brakes	Westinghouse HSC equipment
Maximum speed	110 m.p.h.
Cruising speed	90 m.p.h.
Speed with only one engine operating	68 m.p.h.
Seating capacity	160 persons
Weights and dimensions:	
Total length	207 ft.
Maximum width	9 ft. 10¼ in.
Maximum height above rail	11 ft. 3 in.
Light weight power truck, No. 1	80,855 lb.
Light weight articulated truck, No. 2	43,899 lb.
Light weight articulated truck, No. 3	44,373 lb.
Light weight power truck (boiler end of train), No. 4	79,489 lb.
Total light weight of train	248,616 lb.
Light weight per horsepower	310 lb.
Weight of each power truck complete	25,480 lb.
Weight of each articulated truck complete	12,908 lb.
Weight of one engine without bed	8,910 lb.
Combined weight of one main and auxiliary generator	5,750 lb.
Weight of one fabricated engine bed	7,940 lb.

The interior of one of the passenger compartments

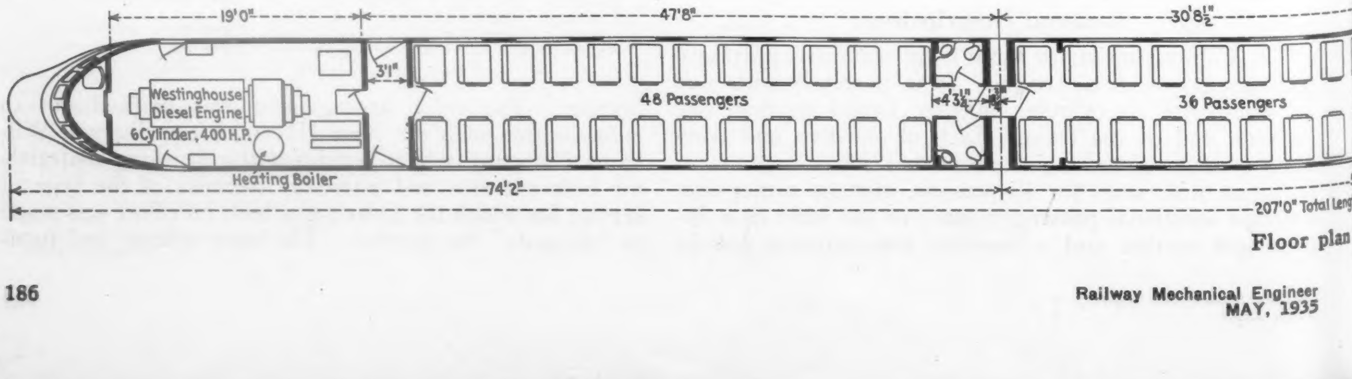
ishings were selected to provide a simple, but attractive effect that would take advantage, to the greatest possible extent, of the natural effects of the materials used. The ceilings are finished in a pink-white and three shades of tan predominate in the side-wall color, clear varnish being used on all moldings, window frames, baggage racks and bare or unpainted surfaces. The seats have aluminum frames with rust-colored mohair upholstery which harmonizes with the inside of the window drapes, the outside of the drapes being a rich ultra-marine blue to correspond with the blue belt of the exterior at the window level. Indirect lighting provided by 25-watt lamps spaced at intervals of 10 in. in a lighting trough furnishes a softly diffused light throughout the interior, having illuminating values of from six to eight foot-candles on a 45-deg. plane 33 in. above the floor. The exterior lighting is provided by marker and classification lamps in sunken wells so as not to interfere with the smooth exterior of the train, and headlights at each end are equipped with 500-watt and 250-watt lamps which, respectively, throw horizontal and vertical beams.

Aerodynamic Considerations

In designing the Comet the engineers of the Goodyear-Zeppelin Corporation were faced with a somewhat different problem in view of the fact that the train is intended for operation in both directions and that due to the necessity of meeting a fast schedule between two points—only 43.8 miles apart—it was necessary to reduce air resistance to a minimum in order that the selected power plants of relatively low horsepower would be able to give the required performance.

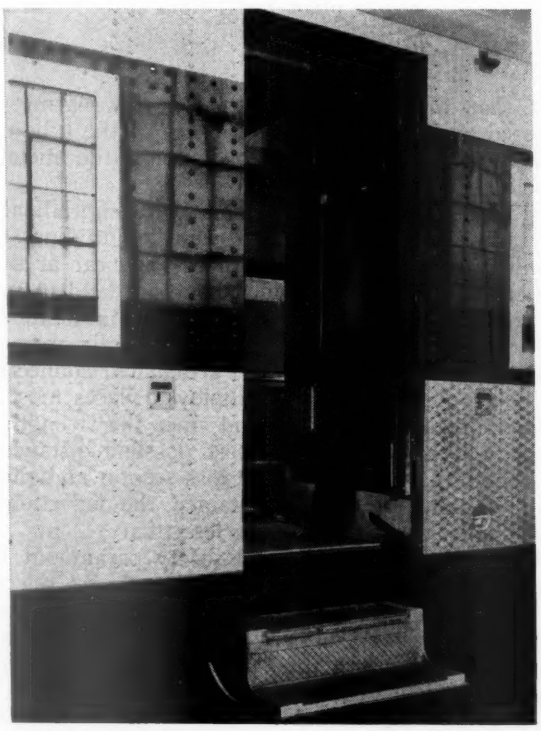
It was not only necessary to investigate the resistance the train would be required to overcome at a given speed, but also of other forces exerted by the air on the moving train. When it is considered that trains, such as the Comet, weighing less than one-half the weight of standard equipment and running at much higher speeds, it appears that the influence of the air forces are of greater importance than those of weight and other forces acting on the train. Other considerations were the necessity of being able to take curves at high speed and to offer the same margin of safety against overturning as standard equipment. Since centrifugal force acting at a given speed is proportional to weight lightness of the train has no influence upon the balance between these two mechanical forces. Nevertheless, to permit a higher speed through a given curvature this train was designed with a lower center of gravity; hence, lateral wind force which can be attributed to the overturning moment increases with train speed for a given wind velocity, and train shape, the margin of safety against their effect, would be reduced as speed is increased. It was, therefore, necessary to select a shape which would not decrease the margin of safety against overturning and at the same time give sufficient stability against swaying.

A series of models was made and tested in wind tunnels, the first models being based on the general



Floor plan

knowledge of aerodynamics with later modifications of new models incorporating the experience of the initial tests. In this manner the best aerodynamic shape was selected. The train, however, is not streamlined in the exact sense of the term because of the limitations of the necessity of operating double ended on existing trackage. The problem was to design the front and rear ends for a cylindrical center section so that the complete train would have a minimum of air resistance. The center section also had to be built for minimum air resistance requiring not only a smooth unbroken surface, but also a shape which in combination with the two ends produced a minimum diagonal and side force for both head and side wind conditions. The final solution was a symmetrical train, alike at both ends and made so that the resistance is low while heading into the air and trailing out. There are no sharp corners and flush surfaces are general, even the headlights being streamline, and the marker lights and horn are covered by the outer surface. The arched roof and rounded corners help to reduce head resistance and side force. The bottom of the cars is also smooth and the trucks, instead of being separately cowled, are placed as far as possible up inside of the body structure, permitting accessibility for maintenance and doing away with cowlings or shroudings which would be exposed to the turbulent air under the cars.



The doors are pneumatically operated and steps fold up when the doors are closed

Wind-tunnel tests on rail cars generally consist of suspending a model in an air stream of variable velocity and measuring the force imposed on the model by means of scales to simulate ground influence in the wind tunnel the simplest procedure consists of suspending a flat board having a well faired leading edge in the proper relationship to the model in the tunnel in such a way that the board does not touch the model. However, this simple expedient fails faithfully to reproduce the motion between the car bottom and the ground, the model and the board both being stationary. For this reason Professor Klemin of the Guggenheim Institute developed a moving belt which can be run at the same speed as the air stream and above which the model can be suspended. Wind-tunnel tests of the models for the Comet were conducted at the Daniel Guggenheim Airship Institute at Akron, Ohio, and in the wind-tunnel of Columbia University, New York.

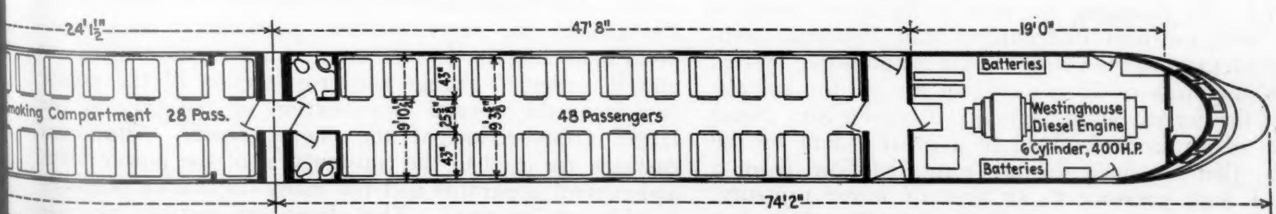
Another novel feature employed during the Akron tests was the use of a boundary-layer cone used to investigate the influence of the length of train on air resistance. The boundary layer is a zone around the car body where air velocity will change from zero to the full speed of the free air stream. This layer of air generally increases in thickness toward the rear end of an object; therefore, by artifically increasing the thickness of the boundary layer the influence of the length of the drag coefficient of the tail can be investigated. This was done by placing a cone-shaped device around the girth of the car model.

The resistance a vehicle has to overcome while moving at a certain velocity is divided frequently into form-drag and skin friction. How the form-drag has been reduced has already been explained. The skin friction, to some degree a function of the smoothness of the outer surface or skin, has also been reduced to a minimum. Windows are flush with the outside of the car, rivet heads have been cut down in height as far as possible without impairing their strength; the gap between the cars has been covered with flat rubber sheeting installed with initial tension.

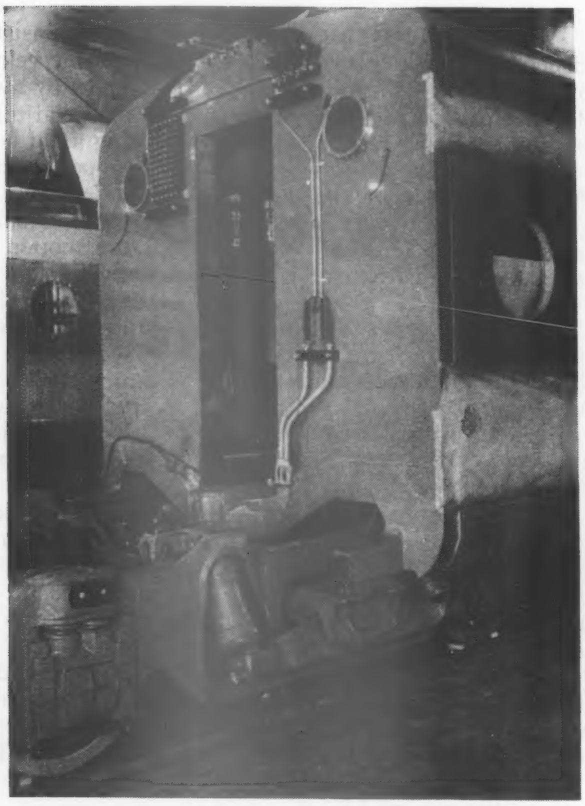
There are no brackets or grab irons on the outside and the doors and steps, when closed, provide an unbroken surface with the rest of the cars. Inevitable projections have been reduced to a minimum; even the air exhaust ventilators are not exposed to the air stream, but discharge the air between the cars while the fresh air is taken in through louvres in the vestibule doors.

The air flow through the radiator system for power plant and air-conditioning compressors presented a greater problem. It was found during the wind-tunnel test that the discharge of the air from the radiators through the roof affected the general air flow to such an extent that the air resistance was increased.

The radiator system of the Comet was built to minimize this disturbance. With two power plants, and therefore two engine rooms—one on each end of the train—the fresh air is taken in on both sides of the rear end of the engine rooms. The air passes first through



Haven's "Comet"

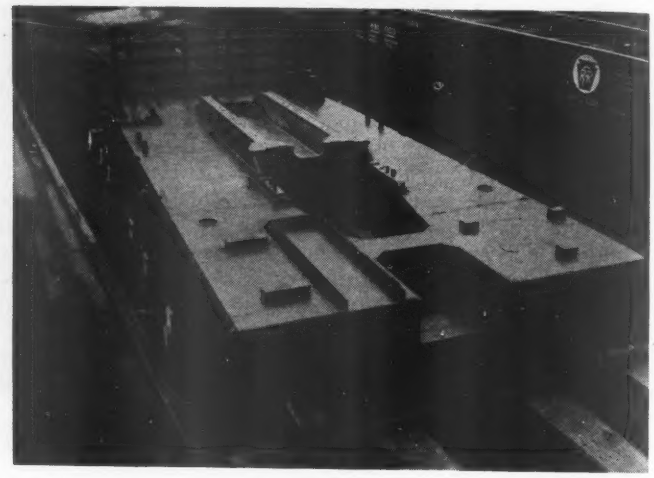


One of the articulated trucks

since the pressure varies along the train and also with the direction of the wind.

Structural Features

The Comet deviates from standard car construction in several fundamental features in that instead of being built on the center sill or truss principle it is constructed as a tube with flat sides and well arched roof and bottom and with shear and compression stresses absorbed by the outer sheets. This principle was used because of the



The power plant bed before installation

a Freon condenser used for the air-conditioning system and then through an oil-cooling radiator. Both of these radiators are attached back of suitable openings in the side wall equipped with a row of deflector vanes. From there on the air is passed through a duct toward the roof and accelerated by an electrically driven blower with thermostatic control. It leaves the car through a water-cooling radiator which is installed just below the car roof where the expelled air is again deflected by another row of vanes.

These deflector vanes, installed at the air intake and outlet, help to correct the air flow and greatly reduce the air resistance, according to the wind-tunnel tests in which miniature blowers had been built into the car model to simulate the air passage. On the actual train these vanes are made so that they can be turned around for the motion of the train in both directions. Cylinders operated by electro-magnetic valves, with air from the air-brake system, automatically turn the vanes at all eight stations so that they will be in the proper relation to the direction of train movement.

While these are the main points where aerodynamic research was required, the air conditioning system required some additional study. In order to assure uniform distribution of conditioned air all over the cars, models of the air conditioning ducts were made and the discharge of air through the holes along the duct was measured. By changing the size of the holes, finally a system with uniform distribution was obtained. Another problem connected with the air conditioning system was the discharge of 25 per cent of the old air and the intake of the corresponding amount of outside air. Since the flow of air is determined to a great extent by the pressure, that is, since the air wants to flow from a region of high pressure to an area of lower pressure, special precaution had to be taken regarding the selection of the point for air inlet and outlet, especially so

fact that in bending and torsion the placing of the stressed material in the outer fibres of the tube circumference makes it possible to employ the metal most effectively.

In place of the center sill and other longitudinal framing of the conventional train, four longitudinal tubular members run the entire length of each car at the four corners of the cross-section. They are held in place by the roof carlines, side posts and floor, and at the end of each car are connected by bulkheads rigidly cross-braced to transmit the stresses to the articulated connections.

The tubular construction employed places most of the material in the outer shell, and since the strength members are located at the greatest possible distance from the center of gravity of the cross-section and the maximum moment of inertia is obtained, the deflection in the fully loaded cars is said to be less than $\frac{1}{16}$ in.

With weight reduction and safety paramount factors in the design of the Comet, aluminum was selected as the main structural material. The metal was furnished by the Aluminum Company of America and this company cooperated with the car builder in developing the necessary extruded shapes.

The four longitudinal tubular members are formed from extruded sections, except for the curved outer portion for which sheet is used. The carlines, floor crossbeams and horizontal connecting members are formed sheet. Alumnium castings are employed in many places throughout the superstructure, particularly as a reinforcement for the lower longitudinal tubular members and in order to change the cross-section of the power car from the normal cross-section of the cars to the larger cross-section of the engine room. Aluminum castings are used in the construction of the power plant and control apparatus and for many decorative purposes in the car interiors. The aluminum sections are assembled by means of aluminum rivets, driven cold. The

rivet alloy was selected after a series of tests at the Goodyear-Zeppelin plant in Akron. The Comet is the first train which has been built with aluminum rivets throughout.

The four longitudinal tubular members are tied into heavy welded-steel end sills through the end bulkheads. These longitudinal members are so designed that it is possible to place the doors at any point on the sides of the cars, except over the trucks, and, in the case of the Comet, the center of each car was considered the most desirable location. The center vestibules are formed by two strong diagonally braced bulkheads, while diagonal members provide lateral rigidity at the corners of the end bulkheads and help carry the stresses of shock up into the circumference of the tubular car body. Since the shear is least at the center of the car the shear deflection is reduced appreciably by placing the door at this point. The doors and folding steps, pneumatically operated, are flush with the outer contour of the train when closed.

The underframe is formed by connecting the two lower longitudinal tubular members with transverse floor beams, spaced 39 in. on centers and having a depth of 21 in. at the center. These are braced by supplementary longitudinal members, forming a series of rectangular compartments in which a few parts of the equipment are located and easily accessible through trap doors in the floor. The under side of the underframe is formed from sheet attached to the floor framing.

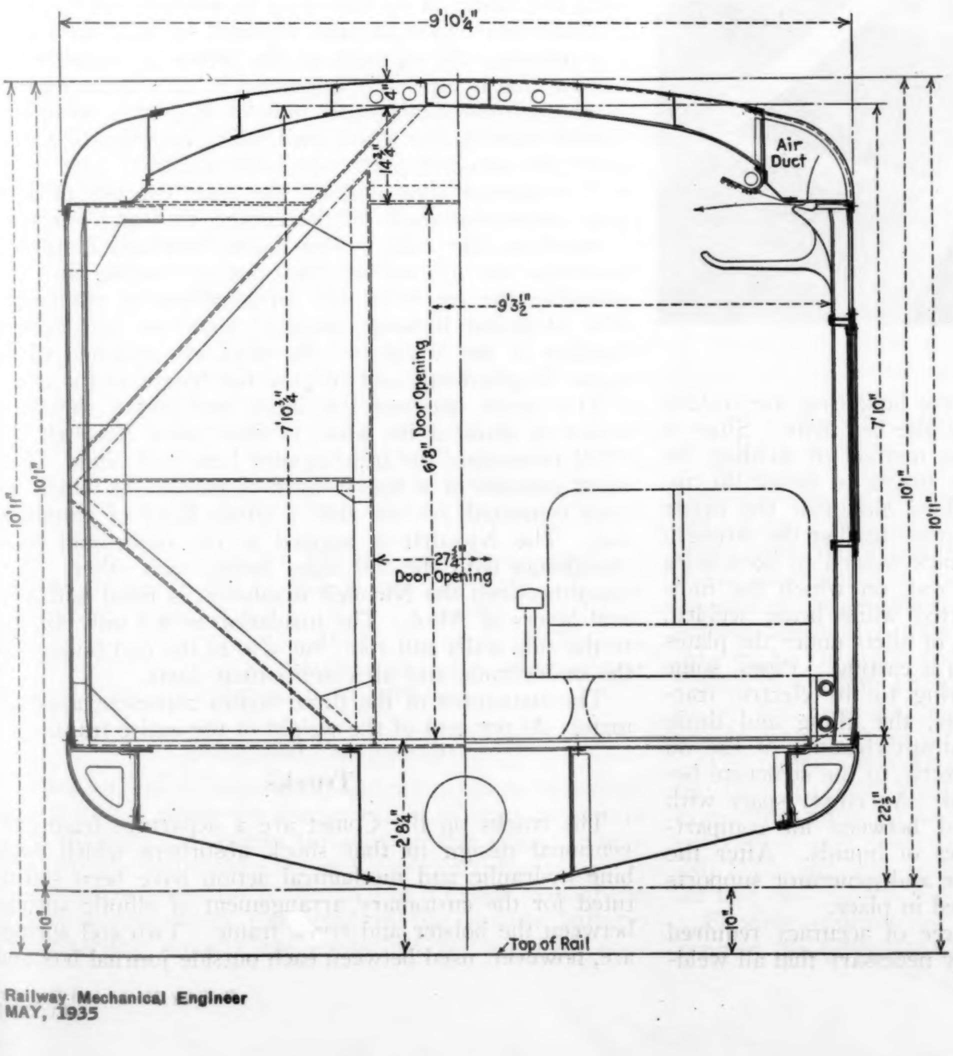
The car floor consists of Keystone flooring with cork filler and ½-in. sheet cork as insulation. Rubber is employed throughout the compartments as the top flooring.

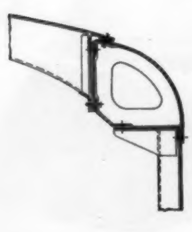
The roof structure is formed by connecting the two upper longitudinal tubular members with pressed sheet carlines, spaced 24 in. to 27 in. on centers and braced longitudinally by six intermediate purlines. The roof is covered with heavy-gage sheet and is designed with small panels to provide an extremely rigid structure capable of carrying a heavy bending load without wrinkling.

The clear standing height in the center of the car is 7 ft. 10¾ in. The door openings are 6 ft. 8 in. high. The windows, which are 51 in. by 26½ in., are separated by window posts 24 in. wide. The panels next to the end bulkheads are more than 60 in. wide in order to accommodate the diagonal braces of the end bulkheads.

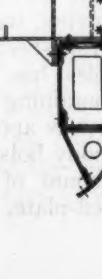
The two end body units have the same type of construction as the center unit except for the extreme ends in which the power plants are located. For the support of the power plants in the aluminum-alloy car-body structure, welded Cromansil-steel bed plates are used, which replace part of the car under-structure over the trucks. The bed-plates are approximately 19 ft. long and, extending over the full width of the car, form not only the lower portion of the crankcase and the generator support, but also the body bolster with its side and center bearings, and all brackets required for mounting auxiliaries and the tie-in with the rest of the structure.

The bed-plate is formed from two plates, one on the top and one on the bottom, and longitudinal and transverse bulkheads, which create a series of compartments used for the storage of fuel, lubricating oil and water.





Two half sections through the passenger compartments are shown at the left and above and below are sections of the tubular members in the power cars



(Above)—Roof and side framing and bulkhead bracing as well as two types of insulation. (Below)—The underframe during construction

The longitudinal and transverse bulkheads are welded on both sides to the bottom of the bed-plate. Since it was impossible to use the same method of welding for the top sheet, it was made in pieces to cover the individual compartments and welded alongside the upper edges of the bulkheads. To increase further the strength of this weld a ¼-in. rod was tack-welded to both sides of the bulkhead edges. This rod, on which the individual top pieces were supported while being welded, served as forms for the creation of fillets under the plates equivalent to those obtained on a casting. Pipes, some serving as conduit for the wiring to the electric traction motors, others for sanders, the filling and drain connections and also for the steam cleaning of the oil compartments, were welded directly to the structure before the top sheets were applied. An empty space with drain holes has been provided between all compartments containing different types of liquids. After the top plate was applied the engine and generator supports and the body bolster were welded in place.

On account of the high degree of accuracy required for the bed-plate, it was not only necessary that all welding operations be performed in a jig, but in addition some forming operations were required during the various stress-releasing heat treatments. After the bed-plate was completed, it had to be accurately machined not only to make a tight crankcase and for motor-generator alinement, but also to provide the correct dimensions between center and side bearings and the rest of the structure.

To assure tightness of the various compartments they were tested under pressure and liquid soap applied at all points where a possible leakage might occur.

To facilitate the removal of the engine from the car, a section of the roof immediately above the bed-plate is removable.

Each end of the train forward of the power plants involves a design which contributes to extreme rigidity. The two lower longitudinal tubular members are formed into a horizontal arch at the end of the car and riveted into a welded-steel structure. The lower portion of this welded-steel member forms the pilot, while the rear portion is connected to the floor structure and to a heavy shear plate. It also forms the pocket for the stationary draft gear and a removable coupler which is carried inside the train when it is not in use.

The front post, which is connected with the welded-steel front member, is tied in with two arches composed of the upper and lower edges of the window-frame girders and on the top it flares out in the form of a Y into the two upper longitudinal members which are arched to meet it.

The entire framework is covered with heavy-gage aluminum-alloy plate, as is the bottom of the underframe. This results in a stiff shell reinforced by the framework, window posts and bulkheads. The front ends are designed so they may be removed at the front engine-room bulkheads and replaced by new ones without reducing the strength at the points of connection, a feature that is especially important in an articulated train where serious damage to one of the ends ordinarily would result in the whole train being kept out of service until the damaged parts had been repaired.

The interior sheathing for the train consists of light-gage aluminum sheet on the curved roof and Haskelite Plymetl on the sides. The upper longitudinal tubular members are utilized as ducts for circulating and distributing the air from the air-conditioning equipment The extruded lighting troughs, used for the indirect lighting of the interior of the cars, are attached to the upper longitudinals and run the full length of the car.

The space between the inner and outer sheathing, which is about 3 in. wide, is filled with Nicolfelt and Alfol to insulate the train against heat and sound. Nicolfelt consists of a heavy layer of hairfelt to which has been cemented, on one side, a single layer of aluminum foil. The Nicolfelt is applied to the outer and inner sheathings with the foil sides facing each other. The space between the Nicolfelt insulation is filled with several layers of Alfol. The insulation is not only applied to the side walls and roof, but also to the end bulkheads, the underframe and air-conditioning ducts.

The structures of the three bodies represent approximately 20 per cent of the weight of the entire train.

Trucks

The trucks on the Comet are a departure from conventional design in that shock absorbers which combine hydraulic and mechanical action have been substituted for the customary arrangement of elliptic springs between the bolster and truck frame. Two coil springs are, however, used between each outside journal box and

the truck frame. Each of the four trucks on the train have frames furnished by the General Steel Castings Corporation. The bolsters extend through the side frames and an equalizer is fulcrumed at its center in a jaw at each end of the bolster. Between each end of each equalizer and the truck frame is a hydraulic shock absorber furnished by the Cleveland Pneumatic Tool Company. The static load on the shock absorbers is carried by heavy coil springs within the shock-absorber casing. The movement of the springs due to any variations in the load is resisted by a hydraulic piston, the action of which is governed by a metering orifice through which the fluid within the casing must flow from one side of the piston to the other. The train is virtually suspended on a cushion which permits it to "float" over crossovers and rail joints with a minimum of shock being transmitted to the car body. The shock absorbers, four to each truck, are similar to, but much heavier than, those employed on aircraft landing gear. Stucki side bearings are used at the bolster ends.

The power trucks, each having two traction motors, are equipped with 36-in. diameter rolled-steel wheels. The trailing trucks are equipped with A.S.F. roller-bearing wheel-and-axle units. The wheels are 30 in. in diameter. All axles are mounted in Timken roller bearings. Simplex unit-cylinder-type clasp brakes are used on all four trucks.

Power Plant

The power plants, each consisting of a six-cylinder, 400-hp. Diesel engine and generators, were designed and built by the Westinghouse Electric & Manufacturing Company. Both power plants are identical. The Diesel engine operates on the four-cycle principle, having six cylinders of 9-in. bore by 12-in. stroke, developing 66.7 hp. at 900 r.p.m. The weight per horsepower is 30 lb., exclusive of generator, and, including the generator, 45 lb.

Engine speed is controlled by an electro-pneumatic governor operator, actuated from the master controller, which regulates the supply of fuel oil to the engine, in conjunction with the oil-pressure-type governor; likewise automatic timing is effected, for each engine speed notch on the master controller, through the operation of the fuel pump timing mechanism which controls the operation of an individual duel pump for each cylinder.

Protection against overspeeding is afforded by an overspeed governor, and against low lubricating oil pressure by a pressure piston, both of which actuate the fuel pump tripping device to by-pass the fuel oil around the pump and stop the engine. The engine may also be shut down by remote control from the operator's compartment, when air pressure is available, by energizing an electro-pneumatic tripping mechanism, mounted at the front of the engine.

In connection with the Diesel engine force-ventilated radiating systems are provided—one for cooling the engine-jacket water and the other for cooling the lubricating oil. The operation of the motor-driven blowers is controlled by a thermostat located in the water system and by manually operated push buttons.

Electrical Equipment

Each engine drives a main and an auxiliary generator which supply power for the operation of traction motors and auxiliary apparatus throughout the train. There are two traction motors on each power truck.

The main generator is operated as a motor to start the Diesel engine when connected to the storage battery. The starting circuits are controlled by magnetic contactors which are operated from the starting push buttons in the engine room for initial starting (cold engine, no air pressure, etc.). To restart the engine after short layovers, if air pressure is available, the starting contactors may be remotely controlled from either operator's compartment. The battery is an Exide Iron-clad, consisting of 56 cells, arranged in tiers on either side of one of the engines.

During idling, the main generator is used through the starting connections to charge the battery and, at the same time, to operate the air compressor and radiator-blower motor. As the throttle lever is notched out and the engine speeds up, the auxiliary load is transferred from the main generator to the auxiliary generator so that air-compressor operation and battery charging are obtained virtually at all times.

The power for the air-conditioning compressor motor is supplied from the auxiliary generator during idling and engine power periods. Manual control is provided to transfer the power circuits to the main generator for pre-cooling and extended idling periods.

The control circuits are energized from the battery, being independent of the engine speed. A 110-volt lighting system is used.

The speed and direction of motion of the train are controlled by the master controller, through the operation of various switching devices which are grouped together in control cabinets.

On the meter and gage panel at each control station are mounted the load and battery ammeters, main generator voltmeters, engine lubricating oil and cooling water gages and a warning signal light indicating high-temperature jacket water at the opposite end of the train.

Air Conditioning

The Comet is air conditioned by a Westinghouse system having 14 tons refrigeration capacity. Two Freon compressors are driven by direct-connected d.c. motors of 12 hp. each. One of these power units, together with its condenser and liquid receiver, is mounted in each of the power compartments at the ends of the train. The compressor and motor are mounted on a common bed-plate which in turn is mounted on the car floor. The condenser is divided into two sections. A section is located on each side of the car at the intakes for the air to the engine-cooling radiators. With the volume of air required by these radiators passing through the condenser pressures may be kept to minimum values under adverse conditions.

Two evaporator and blower units are provided for each body section of the train. Each unit consists of the evaporator coils, heating coils, fans and motors, the expansion-control apparatus and the drip pan. The units are mounted side by side in the center of the car directly over the entrance and encroach less upon head room than would a single unit of like capacity. On account of the greater seating capacity of the center body section, these two units have a cooling capacity of 2½ tons each. For the end sections 2-ton units are used. Each 2½-ton unit circulates approximately 1,000 cu. ft. of air per min. and the 2-ton unit circulates approximately 800 cu. ft. of air per min.

The blowers deliver air to the ducts on each side of the cars in both directions from the centrally located evaporator units. The heating coils is provided in each evaporator unit and has sufficient capacity to deliver 240 B.t.u. per min. to the car with 70 deg. F. entering air and two pounds steam pressure in the coils

Flexible connections similar to flexible metal hose connect the refrigerant lines between cars at roof level.

High-Speed Air-Brake Tests*

By Joseph C. McCune†

Burlington Zephyr stops from speeds up to 100 mph. develop important data on brake action at super speeds

PRIOR to the Zephyr tests, which were conducted on the Chicago, Burlington & Quincy near Earlville, Ill., in October, 1934, much controversy existed as to adhesion values at high speed. The situation was not unlike that prevailing in 1878, prior to the Galton tests, when uncertainty and controversy as to the friction of brake shoes hindered brake development. Correspondingly, doubt as to adhesion values in the recent past made it uncertain whether the new high-speed trains could be stopped in reasonable distances. Probably the greatest value of the Zephyr tests, as affecting future brake development, lies in what was learned about adhesion at high speeds.

Another kind of information, obtained during the tests, of far-reaching influence, was that secured with respect to the behavior of brake shoes and wheels during emergency brake applications from high speeds. For the first time, the behavior of shoes and wheels was recorded in stops from initial speeds of 100 m.p.h.

In addition, information in respect to the action of the retardation controller was developed and as well, curves of stop distances for service and emergency brake applications. The knowledge gained will be discussed in greater detail in what is to follow.

To bring about a stop, all of the energy possessed initially by the train must be converted to energy in some other form, since energy cannot be destroyed. Consequently, large quantities of heat are generated during a stop. Some conception of the quantity of heat involved may be gained by considering what has happened prior to the initiation of the stop. To attain a speed of 100 m.p.h., the train has operated for perhaps 15 miles with wide-open throttle and under favorable grade conditions. During this 15 miles, the engine, say, of 600 hp., has been converting heat into mechanical energy. All of this heat, except as reduced by inescapable losses, is stored in a train as kinetic energy and, when motion of the train is arrested, it reappears as heat. Heat is, therefore, generated whenever the speed of the train is reduced through brake action.

Service or emergency brake applications, braking ratios, brake-shoe loads, modify the effects of heat, but heat, as such, is inevitably produced whenever the train is stopped. One advantage of light-weight trains not always considered lies in the reduction of the heat generated during brake applications. In stopping a train from a given speed, the lighter the train the lesser the problem of dissipating the heat produced during the stop. If trains are to be operated at ultra-high speeds, the weight of the train is of great moment from the braking viewpoint.

Adhesion at High Speeds

The foregoing has dealt with the energy contained in high-speed trains and its transference into heat. But in considering an actual stop from high speed, immediately one factor becomes of the greatest consequence; that is: "What adhesion is available throughout the stop?" A train is actually stopped by the retarding force set up between wheel and rail by action of the brakes—the magnitude of this force is dependent upon adhesion. Obviously, if the adhesion is low, the retarding forces must be low and consequently the stop long. Particularly, if the adhesion is low at very high speeds, long stops must be expected because the retardation is least when the speed is greatest. To make a short stop, the retardation should be high when the speed is high because then the greatest distance is being covered per unit of time. Evidently, adhesion at high speeds is of the greatest importance in obtaining reasonable stop distances from high speed.

The evidence at hand indicates that no major reduction in adhesion occurs at high speeds. This conclusion is of the greatest practical consequence because it establishes that high retardation can be set up at high speed without wheel slippage. By means of special apparatus, which guards against slippage at lower speeds, it is possible to use higher braking ratios than formerly. These higher braking ratios will bring about greater retardation at the top speeds of retardation corresponding to that now obtained at the lower speeds. This is permissible because the Zephyr tests have shown that the adhesion at high speeds is not radically different from that existing at the low speeds. Consequently, it appears physically possible, after further development and experience, to stop trains of the articulated type from speeds of 90-100 m.p.h. in about the same distance as locomotive trains from speeds of 60-70 m.p.h.

Brake Shoe and Wheel Performance

Tests with the Zephyr established that although the brake-shoe friction varies with speed, it varies in a uniform manner from the lowest to the highest speed. No evidence was found to support the view that brake-shoe friction alters markedly after some relatively high speed is attained. Tests from the 100 m.p.h. zone were entirely consistent with stops in the lower speed zones.

It has always heretofore been found that an increased braking ratio produced a shorter stop for any speed within the range encountered in the test. Prior to these tests it was thought possible that a negligible gain might be experienced as a result of an increased braking ratio at very high speeds. Such results were not actually found. At a nominal speed of 100 m.p.h., a reduction in the braking ratio from 175 to 135 per cent lengthened the stop about 600 ft.; a reduction to 123 per cent added some 300 ft. additional; a reduction to 97 per cent lengthened the stop again by some 800 ft.

In the 80-90 m.p.h. speed zone, wheel slippage did not result from application of braking ratios of 330, 305, 290, 275 and 265 per cent. It should be understood that these braking ratios cannot be compared to conventional braking ratios which are maintained throughout the stop. The test braking ratios were applied at a

* Abstract of a paper presented before the Western Railway Club, March 18, 1935.

† Assistant director of engineering, Westinghouse Air Brake Company.

constant high speed. These tests indicate that very high braking ratios can be applied at high speeds, if protective apparatus is supplied to guard against wheel slippage at low speeds.

The Zephyr tests supplied an opportunity, for the first time, to observe, in actual train tests, the performance of brake shoes (Diamond S, chilled) under the combined influence of heavy loads and very high speeds. The performance noted was satisfactory and normal under all conditions. That is, the degree to which the shoe was heated increased with the shoe load and the speed while the amount of metal removed increased with increase in these two factors but not to any disturbing extent. With high energy dissipation rates, the molten metal from the brake shoe would adhere to the wheel but much of it was of a flaky character and only temporarily attached. That portion more permanently fastened to the wheel produced no discernible bad effects.

The rate of brake shoe wear was not as rapid as anticipated. During the entire tests only seven shoes were replaced and five of these were renewed prior to the tests proper because they previously had been worn to a degree which it was believed would not permit them to last throughout the contemplated test program.

In considering brake-shoe wear, it must not be overlooked that great quantities of energy must be converted into heat when stopping the new trains from high speeds and that some kind of apparatus must take up this heat. It is doubtful if there is any cheaper or more satisfactory method of accomplishing this end than by heat absorption in the brake shoes. Furthermore, the most rapid wear of the brake shoes takes place during emergency applications from high speeds, which are of infrequent occurrence. It would appear that the advantage of securing relatively short stops is tremendously more important than reducing the rate of shoe wear.

Prior to the tests, there had been concern that the motor truck wheels would become overheated due to the heavy braking and the weight on the motor axles, which was approximately 50,000 lb. Consequently, portable pyrometers were employed to read wheel-tread temperatures as soon as possible after the completion of the stops. In the four stops from a nominal 100 m.p.h. speed, the tread temperatures on the first wheel read were 480, 390, 350, 240 deg. F. In the other tests, a temperature as high as 300 deg. F. was seldom observed. These readings, as well as visual inspection, indicated no distress in the wheels from the extremely severe braking conditions.

The apparatus which recorded wheel revolutions permitted an investigation of the behavior of the wheel during a slide. Galton found during his tests that an appreciable time interval was required to arrest rotation of the wheels but modern data has heretofore been completely lacking. The Zephyr tests supplied the first up-to-date information in this connection. It was found that, when at a speed of 25 m.p.h., sufficient pressure was manually admitted to the brake cylinder to cause sliding, the slide did not take place immediately but instead about one second was required before the revolution of the wheel ceased. Likewise, about the same time was required for the wheel to acquire car speed again. The interval between dying down and building up is determined by how quickly the cylinder pressure is released and, since this was done manually it is not known at precisely what instant the cylinder pressure was exhausted.

Effect of Retardation Controller

The Zephyr is equipped with a retardation controller which responds to the retardation of the train. Whenever retardation attains a predetermined value, further admission of air to the brake cylinder is cut off. If the retardation thereafter increases to a predetermined higher value, cylinder pressure is released. By electrical means, one controller governs all cylinders in the train.

The retardation of the train is brought about by the combined action of the retarding forces set up between wheel and rail at each of the four trucks due to the brake application on these trucks. It is obvious that the retarding force between wheel and rail at one truck may not bear the same relation to the weight on the truck as exists at some other truck. But if this ratio becomes too high (that is, exceeds the coefficient of adhesion) sliding will occur. Stated differently, one truck may be so overbraked that wheel sliding is inevitable, while at the same time an adjacent truck may be so underbraked as to make wheel sliding a remote contingency. The retardation controller determines if the train as a unit is overbraked. Consequently, if one truck is overbraked and at the same time another truck underbraked, one condition may compensate for the other so that the train as a unit appears to be properly braked. If the retardation controller, which registers the retardation of the train, is to guard against overbraking on any one individual truck, and at the same time permit a high rate of retardation, obviously the degree of braking must be made the same on all trucks as nearly as practicable.

The degree of braking on the several trucks of the Zephyr did not correspond because, based on actual weights, the braking ratios were not the same. But even if the braking ratios had been identical, different degrees of braking would have been experienced because of the wide variance in brake shoe loading. It has previously been mentioned that the coefficient of brake shoe friction decreases as the brake shoe load increases. Consequently, for trucks with the same percentage braking ratio, the degree of braking will be highest on the truck with the lowest shoe load. In other words, this truck will have the greatest tendency to slide. The braking ratios should not, therefore, in theory, be the same, but should be adjusted in accordance with the truck load, so as to make the degree of braking uniform on all trucks. Unfortunately, no reliable experimental data has heretofore existed to permit such an adjustment. On this account, tests of this kind were made with the Zephyr.

Among other things, these tests again demonstrated that the coefficient of friction increases as the shoe load decreases. For instance, with a shoe load of 4,730 lb., 127 per cent braking ratio will provide a brake equally as effective as 152 per cent when the shoe load is 18,850 lb.

The tests indicated that the type of retardation controller installed should have a difference in its setting of about 1 m.p.h. per sec. to prevent "cycling" and that a release setting of 4.5 m.p.h. per sec. could be employed after the rear truck had been equalized with the other trucks, without intolerable wheel sliding resulting.

Conclusions

Since the Zephyr tests, although of limited duration, were the first in which actual data were secured with respect to some of the more fundamental aspects of the brake problem in zones of very high speeds, tentative conclusions may be drawn with reference to certain heretofore controverted phases of braking performance. Consequently these tests, because of the influence they will probably exert upon the development of high speed, light weight trains, may, in time, rank with the memorable Galton tests of 1878 as a landmark in the art of braking. Tentative conclusions are as follows:

(1) The friction of brake shoes in the 80-100 m.p.h. speed zone is determined by the same influences as in the 60-80 m.p.h. zone. That is, the brake-shoe friction at very high speed is entirely consistent with that heretofore experienced in the lower speed zone and does not, as thought possible prior to the tests, attain normally low values in the 100 m.p.h. zone.

(2) The adhesion between wheel and rail does not change markedly at the highest speed and may be entirely independent of speed, although the independence of speed and adhesion was not established beyond question.

(3) Braking ratios of 300 per cent at speeds of 100 m.p.h. are possible.

(4) Modern brake shoes do not "break down" or melt at the higher speeds as experienced in previous brake tests.

(5) The present 18,000-lb. limit for emergency brake-shoe load may be too low. A nominal shoe-load of 26,000 lb. was used successfully in a stop from 103 m.p.h.

(6) The rate of wear of the brake shoes is not abnormally increased by stops from 100 m.p.h.

(7) The car wheel showed no distress in a stop from 103 m.p.h. with 26,000-lb. shoe load.

(8) The car wheel requires an appreciable interval to cease revolving during a slide.

(9) The coefficient of brake-shoe friction decreases as the shoe load increases. A braking ratio of 127 per cent with 4,730-lb. shoe pressure was as effective as 152 per cent with 18,850-lb. shoe pressure.

(10) An inertia device, the retardation controller, permitted high braking ratios at high speed because it limited the braking ratio at low speeds.

(11) The brake equipment installed on the Zephyr was effective and flexible, although handicapped by a low braking ratio.

(12) No fundamental physical limitations were found which would preclude, with further development in the brake art, stops of trains of the Zephyr type from 90-100 m.p.h. in the approximate distances required for every-day conventional locomotive trains from speeds of 60-70 m.p.h.

Heat Transmission in Boilers

(*Continued from page 184*)

difference between mean gas and mean steam;—

$$ks = \frac{\text{column 10a}}{R_2 \times \left\{ [(b - c) / (\log_e b/c)] + tw \right\} - (ts - tw) / \log_e ts/tw} \quad ..(7)$$

in equations (2-7) inclusive

a = temperature at firebed — tw
b = temperature at tube entrance — tw
c = temperature in smokebox — tw
tw = temperature of saturated steam in boiler
ts = temperature of superheated steam in branch pipe
R = ratio of firebox heating surface to grate area
R_1 = ratio of tube and flue heating surface to grate area
R_2 = ratio of superheating surface to grate area
$\log_e$ = hyperbolic logarithm
970 = B.t.u. required to convert one lb. of water into steam, from and at a temperature of 212 deg. F.

In all calculations R_1 is based on the water side of tubes and flues and R_2 on the steam side of superheater pipes, this being the practice generally followed. All calculations are based on one square foot of grate area, which is considered a microcosm of the entire boiler. The term sfg/hr. wherever used, is equivalent to "one square foot of grate surface per hour." The principal characteristics of the various locomotive boilers for which test data are shown, are given in Table 20.

Two of the locomotives selected for this discussion are equipped with a feedwater heater, there is also a wide difference between the various boilers in pressure, feedwater temperature and branch pipe temperature. To equalize these differences and to facilitate comparison, all calculations have been based on equivalent evaporation from and at 212 deg. F.

(*To be continued*)

B. & O. Builds Locomotives

(*Continued from page 179*)

Both locomotives are fitted with vestibule cabs and the windows are provided with Duplate shatter-proof glass.

Air Compressors and Reservoirs on the Tender

The air-brake equipment, Schedule 6ET, was furnished by the New York Air Brake Company. The foundation brake gear is provided with brake shoes on the engine truck, drivers and front wheels of the trailing truck. In order to produce a locomotive with clean lines the duplex air pump and the main reservoirs were removed from the locomotive and mounted on the tender. The air pump has been placed in a horizontal position on the right side of the tender between the back of the coal space and the water-filling hatch. In order to provide for the successful operation of the pump in this position spring-seated air intake and discharge valves have been applied throughout. No other alteration in the compressor was necessary aside from a change in the location of the steam drains. The steam cylinders are lubricated by a Nathan single-feed mechanical lubricator arranged to be automatically operated by the stroke of the pump.

The main reservoirs are located between the trucks underneath the tender frame, one on each side. These reservoirs are fabricated from Byers wrought-iron and are fitted with Huron wash-out plugs.

Both locomotives are equipped with Loco Valve Pilots and the General Railway Signal Company train control, Schedule No. 2. The train-control case is placed on the left side of the tender top, opposite the air pumps, as is also the headlight generator.

To conform with the coaches the rear ends of the tenders of both locomotives have been equipped with diaphrams which extend out to the roof and side lines. Special safety appliances have been applied so that, when the locomotive is not attached to a train, access may be had from the ground to the space between the inner and outer diaphragms where a ladder on the rear of the tender leads to an open hatchway to the top of the water tank.

The tenders are fitted with O-B Tight-Lock couplers with integral connections for steam and air as well as for the electric circuits. As the cars are provided with electric circuit cab-signals the locomotives are equipped with an electrically operated buzzer signal. Owing to the possibility of using the locomotives with other types of passenger rolling stock they are also fitted with the usual pneumatic signal equipment and train line. In the case of such operation hose connections for the air-brake, signal and steam lines are provided. These can be cut in and the automatic connectors on the coupler disconnected whenever occasion requires. The possibilities offered by the electrical connectors has been taken advantage of to provide for telephone communication between the baggage car and the locomotive cab when the locomotives are operated with the new passenger coaches.

The tender for the 4-4-4 type locomotive has a capacity for 14 tons of coal and 8,000 gallons of water; that for the 4-6-4 type locomotive a capacity for 16 tons of coal and 10,000 gallons of water. Both are fitted with water scoops. Both tenders are mounted on four-wheel trucks with 6-in. by 11-in. journals and 36-in. rolled-steel wheels. All tender trucks are fitted with Fafnir roller bearings.

The locomotives are finished in royal blue without striping, except for the polished metal rods and motion work. The lettering is in gold. The principal dimensions and weights of both locomotives are included in an accompanying table.

EDITORIALS

The Mechanical Associations and Their Future

The annual meetings of the so-called minor mechanical associations, which were tentatively scheduled for the early part of this month, were finally canceled—or, more properly speaking, were allowed to go by default because of lack of encouragement on the part of the higher officers. Finally they were eliminated by the letter from the vice-president in charge of operation of the Association of American Railroads, which was cited in the April *Railway Mechanical Engineer.*

Will Not Give Up!

Fortunately the Committee on Co-ordination of the Mechanical Conventions has not given up hope for the future of these organizations, and is soliciting the support of the Association of American Railroads for the holding of a business meeting of the co-ordinated associations some time next fall. This group is also suggesting to the various associations that they keep their committees at work preparing for such a meeting.

Most of these associations have been dormant for such a long time that it will be a hard fight to revive their activities and get back the old spirit. The Mechanical Division, which will hold a two-day general meeting in June, can undoubtedly be a large factor in stimulating these associations, although the Division itself has not shown the same aggressiveness as have some associations in other departments, which, incidentally, are of no greater importance to the railroads than the mechanical organization. Undoubtedly, however, if the Mechanical Division puts up a strong fight for the minor associations, it will be a large factor in placing them back on their feet.

It is vital, if they expect to continue to exist, that the officers and members of these associations put up a strong and spirited fight for their continuance; otherwise they are quite likely to be lost by the wayside.

Favorable Factors

Many things are happening which indicate that the time is ripe for putting up a strong fight and planning for early meetings of the various organizations. For one thing, there has been some improvement in business conditions. The effect of this, so far as the railroads are concerned, has been partially offset by the increases in wages and costs of material.

Things look more favorable in Congress than they did a month ago. The Senate at last has passed the motor carrier bill. This is so generally endorsed by the public that there is little doubt but what the House will take similar action and that it will receive the approval of the Administration. It is even possible that other legislation favorable to the railroads will be passed by the present Congress.

The railroad clubs, generally, throughout the country have shown more constructive activity and have had larger attendances at their meetings in recent months than for quite some time. Several of them have gone out in determined fashion to increase their membership, and with excellent results. The Boston & Albany Supervisors' Club at West Springfield, Mass., is just closing the most successful season in its life of ten years.

The new high-speed, streamline trains have attracted an extraordinary amount of attention and the public seems to have gained the impression that the railroads are staging a real comeback. Other new high-speed trains and locomotives are nearing completion and will be placed in operation during the month. Meanwhile, several of the railroads have made important improvements or changes in rebuilt locomotives, passenger cars and freight cars. On the basis of the great interest shown by the public in the streamline trains, they have tried the experiment of exhibiting some of this rebuilt equipment. The results have been astounding, measured either by the large number of visitors or the publicity which has resulted.

These things, with others too numerous to mention, are putting courage into the railroad organizations.

Difficulties Ahead

Several letters received during the past month indicate that difficulty is being experienced in getting properly trained workers in railroad shops for certain classes of work made necessary by modernizing the equipment. Many mechanical department officials are also concerned as to how to maintain the new types of equipment which are being introduced.

There would seem to be a large and important place today for meetings of wide-awake, aggressive, constructive mechanical department associations. They have already been dormant entirely too long. A railway mechanical officer of wide experience, epitomizes the present situation in this way: *"If there ever was a time when practical men need to get together and discuss common problems, it is today—but we lack prophets."*

Prophets Needed—and Fighters!

The events through which railroad mechanical officers have passed in recent years have been most discouraging and distressing, but it does seem that the time has now come when they must make a real fight to rebuild their associations. We need prophets and a lot of them, but backing them up we need fighters—men of courage and vision, who realize what it means

to have associations of men, dealing with the practical affairs of the mechanical department, getting together in council to discuss how they can best meet the problems with which they are confronted, and to so improve the equipment and its operation that the railroads can successfully meet and overcome the subsidized competition of other types of carriers.

Important Locomotive Developments in France

American rail transportation, with its long distance movements of bulk commodities in large masses which has resulted in the evolution of our modern heavy-duty locomotives and large-capacity freight cars, has tended to the creation of a belief that railroad conditions on the North American continent are materially different from those in other parts of the world. Passenger trains, as well as freight trains, have also steadily increased in length and weight. To assume, however, that as a consequence there is but little to be learned from other countries may cause some highly important developments to be overlooked. A restudy of the situation in some other countries may show that their conditions are not so widely different from our own as had been assumed to be the case.

At the present moment considerable attention is being given everywhere to increases in passenger-train operating speeds. At the same time, while less is being said about it, there are just as important changes taking place in expediting the movements of commodity freight. In keeping with the thoughts of high speeds, such matters as streamlining and the design of lighter weight rolling stock are receiving much attention. One of the contributing factors has been the spectacular performances of certain high-speed, light-weight passenger trains driven by Diesel engines. If now we turn to other countries, particularly to those in Europe, we find exactly the same trends; in fact, the movement toward higher speeds is practically a world-wide one.

As regards developments of the steam locomotive apparently the greatest advances made anywhere during the past few years have been in France. At the present time some of the recently rebuilt French locomotives are probably among the most efficient of any in the world. Furthermore, they are hauling trains weighing from 600 to 900 tons at unusually high speeds and with a remarkably low ratio of engine weight to weight hauled. These accomplishments are not the result of any sudden step forward, but were made possible by patient research and many long and carefully conducted road and laboratory tests.

The lack of proper research facilities led to the building of a complete locomotive testing plant at Vitry, near Paris, to supplement dynamometer road tests. The laboratory was constructed at the joint expense of the principal railways in France. This testing plant, which was placed in operation in July, 1933, was designed to handle locomotives with axle loads up to 66,000 lb. and with a tractive force up to 100,000 lb. Originally arranged to operate at speeds up to 100 m.p.h., changes were soon made which increased the maximum speed to 125 m.p.h. The dynamometers are capable of recording up to 1,200 hp. per driving axle at 15 m.p.h., or 1,875 hp. at higher speeds. It is to this laboratory that the London & North Eastern Railway 2-8-2 type locomotive, the "Cock of the North," which was described in the *Railway Mechanical Engineer*, February, 1935, page 48, has been sent for test. The only other locomotive testing laboratory in Europe is that belonging to the German State Railways at Grünewald, which was opened in 1930.

Credit for the pioneer work which led up to the recent French locomotive improvements belongs to the Paris-Orleans railway. Preliminary results obtained by remodeling a group of 4-6-2 type locomotives on this road were given in the *Railway Mechanical Engineer*, November, 1931, page 527. Similar work has subsequently been carried out on the Paris-Lyons-Mediterranean, the Nord (North), the Est (East), and the Etat (State) railways.

Several factors contributed to this movement. In the first place, the completion of rather extensive electrification projects had brought about an accumulation of steam locomotives in good condition for which there was no apparent use; in the second place, a growing demand for increased train scheduled speeds was beginning to appear; and in the third place, it is the custom in France and in most European countries not only to maintain locomotives in good operating condition but also by means of extensive rebuilding to put them in shape to perform service far more severe than that for which they had been designed originally. In other places it is possible that a schedule of scrapping old locomotives and building entirely new ones might prove to be more economical.

Character of Improvements Made

Briefly outlined, the modifications were as listed below. All of them were made on the Paris-Orleans locomotives and many of them on the locomotives of other roads.

1—Boiler pressure was increased, being raised to 290 lb. in some cases.

2—A Nicholson thermic syphon was added in the firebox.

3—An improved design of shaking grates was installed.

4—A new and efficient type of Houlet superheater with annular passages, which replaced the superheater previously used. This increased the steam temperature from between 720 and 730 deg. F. to at least 750 deg. F., or even an average of 790 deg. F. at times. It also gave a freer flow of steam through the superheater, and, of course, reduced the fuel consumption.

5—Steam pipes and throttle valves were increased in size and straightened or given smooth curves of large radius in order to deliver steam at practically full boiler pressure to the valve chest.

6—New cylinders were applied which were provided with Dabeg O. C. poppet valves and with improved steam and exhaust passages. This reduced wire drawing. Valves are held open when the locomotive is drifting.

7—The Kylchap double exhaust furnished ample draft and materially reduced the back pressure. A description of this exhaust system as applied on the L. & N. E. was given in the *Railway Mechanical Engineer*, February, 1935, page 48.

8—A.C.F.I. feedwater heater was applied.

9—A recording speed indicator was placed in the cab.

10—In some instances a trailing truck was replaced by an extra pair of drivers, thus converting a 4-6-2 into a 4-8-0 type locomotive.

These improvements have been reflected in increased boiler capacity, higher thermal efficiency, greater rated tractive force, and improved acceleration at high speeds. Horsepower was increased from 50 to 100 per cent (as high as 4,000 i.h.p. being obtained, whereas only 2,000 i.h.p. was obtainable before the changes), and the locomotives have shown an ability to handle longer trains at considerably higher speeds. In conjunction with the changes in design the enginemen were given careful training and a coal bonus system was put into effect.

Performance

As examples of high-speed passenger-train schedules in France the following instances are cited:

(a) On the P.O.-Midi the "Sud" express from Paris to Bordeaux, 362 miles, the scheduled time is 355 min., which includes four stops, one of which is for a duration of 6 min.

(b) On the P-L-M- the run from Paris to Marseilles, 535 miles, is scheduled for 555 min., including five stops.

Many French trains are scheduled for over 60 m.p.h.—start to stop—with intermediate stops. Top speeds up to 80 m.p.h. are not infrequent.

French coaches, while not as heavy as American, frequently weigh from 110,000 to 120,000 lb. A train may consist of 10 to 15 cars. In estimating train weight in France it is customary to add 165 lb. for each passenger with an additional allowance of 65 lb. for baggage.

As an example of operation a P.-O. rebuilt 4-6-2 type locomotive with 76¾-in. drivers and weighing 218,800 lb., with a tender weighing 126,800 lb., hauled a train of 17 coaches weighing 880 tons at top speeds of from 70 to 78 m.p.h. and made a run of 50.6 miles in 50 min., start to stop. In this case the ratio of locomotive weight to combined weight of tender and train was one to 8.6 or a ratio of one to 5.1 for weight of locomotive and tender to that of the train hauled—ratios which are highly creditable for high-speed train operation without recourse to streamlining.

Corresponding changes in locomotives on other French roads have resulted in improvements almost equal to that on the Paris-Orleans and many other examples of high speed running with heavy trains might be cited.

Mechanical Division Meeting

The announcement has been made that the annual meeting of the Mechanical Division of the Association of American Railroads will be held at the Congress Hotel, Chicago, June 26 and 27. The meeting will start at 10:00 a.m., daylight saving time, on the 26th. It is understood that the program will be confined to the presentation of committee reports and discussions; also that the reports will be printed and distributed well in advance of the time of the meeting.

While there will be no exhibits in connection with the convention, it will be an annual meeting of the membership, rather than a meeting of the General Committee with representatives of the subcommittees. This is the first time since 1930 that a full membership annual meeting has been held, and undoubtedly the roads which are not represented on the General Committee or have not had representatives present at the annual meeting of the committee, will avail themselves of the opportunity to be represented and take part in the discussion of those reports in which they may be specially interested.

The criticism has been made in recent years that while all of the member roads have had an opportunity to vote on questions which were submitted to letter ballot, they have not had the opportunity to take part in the preliminary discussions. It is contended that in some instances, at least, the wording of the letter ballots would have been different had all the railroads had an opportunity of presenting their views in advance. Regardless of the merit of this contention, it must be admitted that the General Committee has worked hard and conscientiously under the trying conditions through which the mechanical departments of the railroads have passed in these recent years. Undoubtedly the members of that committee will welcome the opportunity for a larger attendance and more comprehensive discussion of the many difficult problems with which they are confronted.

The Mechanical Designer And Economics

Without attempting to enumerate them all, there are many kinds of economics, including political, social and industrial, not to mention mechanical. The mechanical designer who does not include a good proportion of economics, or, in other words, good, plain, dollars-and-cents horse sense in his design, will never make any real contribution either to the world's standard of living or to his own prestige.

Take, for example, the question of designing a piece of railroad car equipment adapted to meet modern transportation requirements. A wealth of new materials, with improved physical properties, rust- and wear-resisting characteristics, etc., is now available to the modern designer who must, in many instances, balance the advantages of a number of specialized materials for each detail of the car design against the cost of purchasing, applying and servicing these materials in the car structure. In the last analysis, the designer who produces the car best adapted to the service requirements, and at the least unit cost, is the one who is not only building a firm foundation for his own reputation but making a valuable contribution to the art of transportation.

In the field of motive power, also, the dollar sign rules. As was ably pointed out at the recent meeting of the Western Railway Club, the designer must consider each locomotive as an entity, canvass the service requirements, and base his decision regarding not only structural materials but the type of prime mover used upon relative, fundamental costs. In other words, the mechanical efficiency of the locomotive is not all-important. Its thermal efficiency does not tell the whole story. But, its over-all cost efficiency, under the particular operating conditions imposed, presents the final answer.

For the best results, the railway-equipment designer of today as, in fact, in all times past, must be a cost engineer.

With the
Car Foremen and Inspectors

Reconditioned Caboose Cars

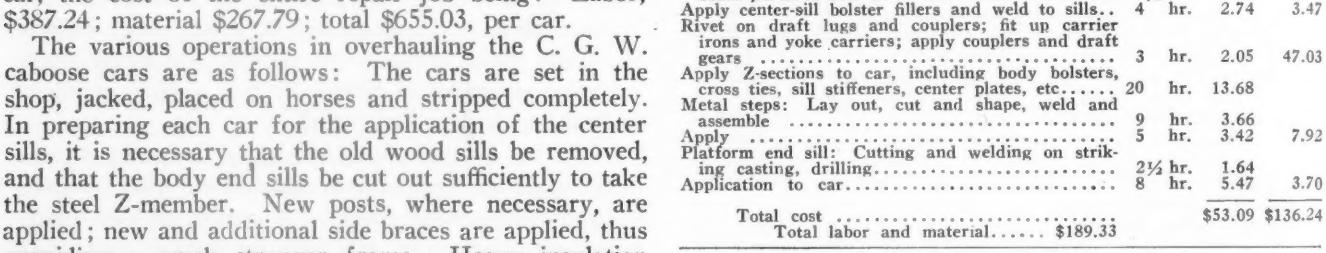
THE Chicago Great Western is completely overhauling and modernizing a number of all-wood standard caboose cars at Oelwein (Iowa) shops. Included in this general repair work is the application of A. A. R. standard Z-section center sills. Type-D couplers and friction draft gears—the Type-D couplers and friction draft gears being reclaimed from dismantled equipment. In addition, six-inch metal I-beam platform end sills are applied, also steel steps. The 60,000-lb.-capacity arch-bar trucks are replaced by 80,000-lb.-capacity Andrews steel side frame trucks, the latter also being recovered from dismantled equipment. The average cost of both labor and material in applying the Z-section center sills and work incidental thereto is $189.33, per car, the cost of the entire repair job being: Labor, $387.24; material $267.79; total $655.03, per car.

The various operations in overhauling the C. G. W. caboose cars are as follows: The cars are set in the shop, jacked, placed on horses and stripped completely. In preparing each car for the application of the center sills, it is necessary that the old wood sills be removed, and that the body end sills be cut out sufficiently to take the steel Z-member. New posts, where necessary, are applied; new and additional side braces are applied, thus providing a much stronger frame. Heavy insulation paper is applied between the framing and the sheathing to prevent air leaks and permit keeping the car warm in severe weather. In connection with the roof construction, these cars originally had double-layer wood roofs. These are being replaced with one layer of wood, one layer of heavy insulating paper and an outside cover of heavy canvas which is treated by the application of

Labor and Material Costs of Applying Z-Section Center Sills, Metal Steps and Platform End Sills to C. G. W. All-Wood Caboose Cars

Operation		Labor	Material
Car jacked, placed on horses; remove trucks, couplers, draft gears, body bolsters, cross ties, air brakes, center sills and platforms	20 hr.	$13.68	
Set up, prepare and weld Z-section center sills	4 hr.	3.00	$67.85
Lay out, burn and ream holes for bolts securing Z-sections to car and for riveting on lugs and other attachments; cutting slots in Z-sections through which top leaf of body bolster passes and top portion of ends of Z-sections to fit I-beam platform end sills	4½ hr.	3.75	6.27
Apply center-sill bolster fillers and weld to sills	4 hr.	2.74	3.47
Rivet on draft lugs and couplers; fit up carrier irons and yoke carriers; apply couplers and draft gears	3 hr.	2.05	47.03
Apply Z-sections to car, including body bolsters, cross ties, sill stiffeners, center plates, etc.	20 hr.	13.68	
Metal steps: Lay out, cut and shape, weld and assemble	9 hr.	3.66	
Apply	5 hr.	3.42	7.92
Platform end sill: Cutting and welding on striking casting, drilling	2½ hr.	1.64	
Application to car	8 hr.	5.47	3.70
Total cost		$53.09	$136.24
Total labor and material $189.33			

(*Continued on page 206*)



Modernized caboose car of the Chicago Great Western on the transfer table at Oelwein shops

A container loaded with triple valves bound for the shop

Repairing

Triple Valves

At Pitcairn Shop

THERE are approximately 270,000 freight cars on the Pennsylvania System that are equipped with the K type of triple valve, either the K-1 (8 in. equipment) or the K-2 (10 in. equipment); there being considerably more of the latter type in service than of the former. In addition to the above equipment there are, at the present time, approximately 10,000 freight cars on the Pennsylvania equipped with the AB freight brake equipment, and all freight cars built subsequent to September 1, 1933, are to be so equipped.

There are four shops on the Pennsylvania which are known as central air brake repair shops—Wilmington, Del.; Altoona, Pa.; Fort Wayne, Ind., and Pitcairn, Pa.—each of which serve a region of the system. As far as freight triple valves are concerned each region has strategically located repair points where facilities are provided for the cleaning of triple valves, but not for general repairing.

The practices described in this article are those which are followed at the Pitcairn Air Brake Repair Shop which serves the Central region. In this region there are five "outlying points"—Conway, Pa.; Mahoningtown, Pa.; Mingo Junction, Ohio; Cleveland, Ohio; and Buffalo, N. Y.—where triple valves which have been removed from cars for failure to function or for periodical cleaning under A.A.R. rules are sent.

As far as triple valves are concerned, the Pitcairn shop is not only a central repair shop but also serves as a cleaning point for all triple valves removed from freight cars on the Western Pennsylvania division.

Methods Used on the K Type Triple Valves

When a triple valve has been removed from a car at an "outlying point" and sent to one of the triple valve cleaning points on the division, it is cleaned and oiled in a manner which will be described later in this article, and then placed on a 3 T standard triple valve test rack. If the valve passes the required tests after cleaning and oiling, it is placed in stock for reapplication, and if it fails to pass the test it is sent to a central shop, such as Pitcairn, for repairs.

For any valve that has been cleaned and fails on a test rack, a form such as shown in Fig. 1 is inserted in the check case before the pipe cap is applied. This form shows the defects for which the valve was condemned, the date it was tested, the shop, and the name of the test rack operator.

Triple valves arriving at Pitcairn are unloaded from cars into containers and brought into the shop at a point which is indicated as "inbound triple valves" in the departmental shop layout drawing shown in Fig. 2. A laborer is stationed at this point whose duties consist of separating the various types of valves as well as separating the valves to be cleaned from those which are scheduled for repairs. A valve destined for repairs is one that has been previously cleaned and fails to pass the test and shows plainly from the outside appearance that it has been worked on. In addition, the form, such as shown in Fig. 1, which was inserted in the check valve case at an "outlying point," designates the repairs to be made and proves that the valve has already been cleaned.

The laborer places the valve on a ledge near the dismantling machine, as shown in Fig. 3, where it is completely dismantled and the parts placed in an individual tray. The loaded tray is then placed on a roller conveyor and transported to the point where the gaging inspector is stationed. Among the gages used is a set called for under the A.A.R. requirements, developed in

M. P. 346
75M-4-4-34—4"x4" W

THE PENNSYLVANIA RAILROAD

Form Showing Defects for Condemning Triple, Distributing or UC Valves

Slide Valve Leakage ____________

Graduating Valve Leakage ____________

Defective Ring ____________ Feed Groove ____________

Defective Body ____________

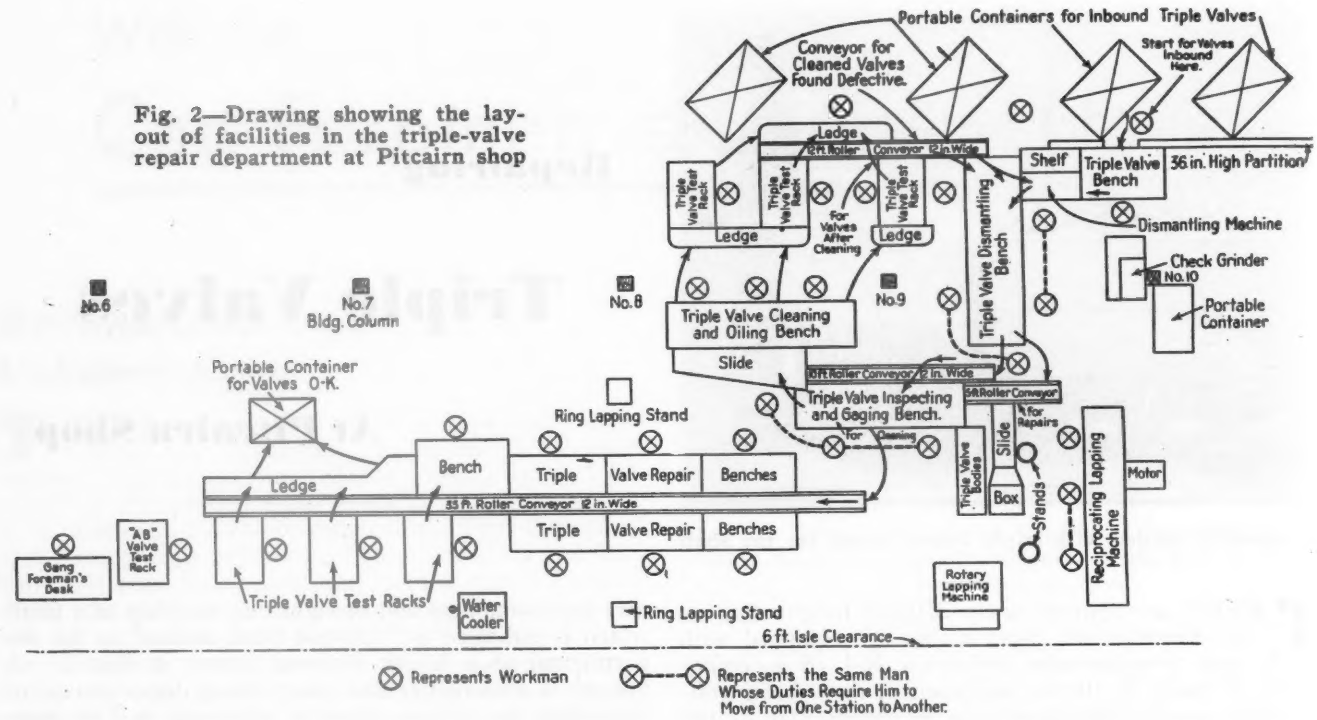
Shop 785 ____________ Date ____________

Name of Test Rack Operator ____________

Note: Mark the name of the items for which valve was condemned. Place form in check case of triple valve before pipe cap is applied. For UC and distributing valve, place form in brake pipe port before metal protector is applied.

Fig. 1—Form used by inspectors for designating inspection or repairs to triple valves

Fig. 2—Drawing showing the layout of facilities in the triple-valve repair department at Pitcairn shop

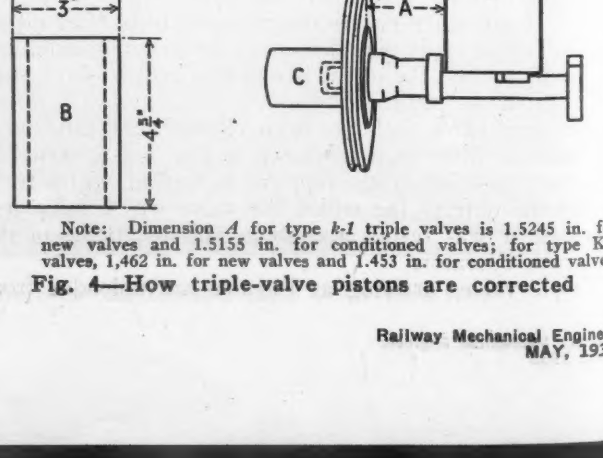


co-operation with the I.C.C. Bureau of Safety. These include:

1. Caliper gage for checking the piston diameter of triple valves. (A.A.R. gage No. 36,954).
2. Caliper gage for checking the outside diameter of the emergency piston. (A.A.R. gage No. 36,958).
3. Flat gage for checking the total wear on the check valve and check case bushing. (A.A.R. gage No. 36,960).
4. Caliper gage for checking the diameter of the emergency piston bushing. (A.A.R. gage No. 36,952).
5. Cylinder gage for checking the diameter of the piston bushing. (A.A.R. gage No. 37,114).
6. Flat gage for checking the thickness of the emergency valve seat flange and the height of the beaded seat. (A.A.R. gage No. 36,961).
7. Caliper gage for checking the diameter of the guide hole in the emergency valve seat. (A.A.R. gage No. 36,962).
8. Flat gage for checking the thickness of the slide valve and the depth of the exhaust cavity. (A.A.R. gage No. 36,956 for K-1 valves and gage No. 37,021 for K-2 valves).
9. Flat gage for checking the thickness of the graduating valve. (A.A.R. gage No. 36,957).
10. Flat gage for checking the height of the graduating stem above the gasket face in the cylinder cap. (A.A.R. gage No. 36,963).
11. Gage for checking retarding device stems. (A.A.R. gage No. 36,964).
12. A device for checking the graduating spring to determine whether or not it meets A.A.R. requirements.

Due to a constant hammering of the triple valve piston head against the cylinder cap gasket, the head bows backward, shortening the distance *A* (Fig. 4) between the piston ring groove and the piston stem collar. This defect has the effect of a long feed groove in the piston bushing, allowing the feed groove to establish communication between the auxiliary reservoir and the brake pipe before the exhaust cavity in the slide valve opens to permit the passage of brake-cylinder pressure to the atmosphere. This is one of the many causes of a sticking brake. When the inspector discovers that this distance is too short, as indicated by the condemning gage, the piston is altered to conform to the normal gage by the following procedure. The piston is placed in a bushing, designated as *B* in Fig. 4, with the stem downward, and another bushing, *C*, is placed over the center of the pis-

Fig. 3—Triple valve dismantling machine



Note: Dimension *A* for type *k-1* triple valves is 1.5245 in. for new valves and 1.5155 in. for conditioned valves; for type K-2 valves, 1,462 in. for new valves and 1.453 in. for conditioned valves.

Fig. 4—How triple-valve pistons are corrected

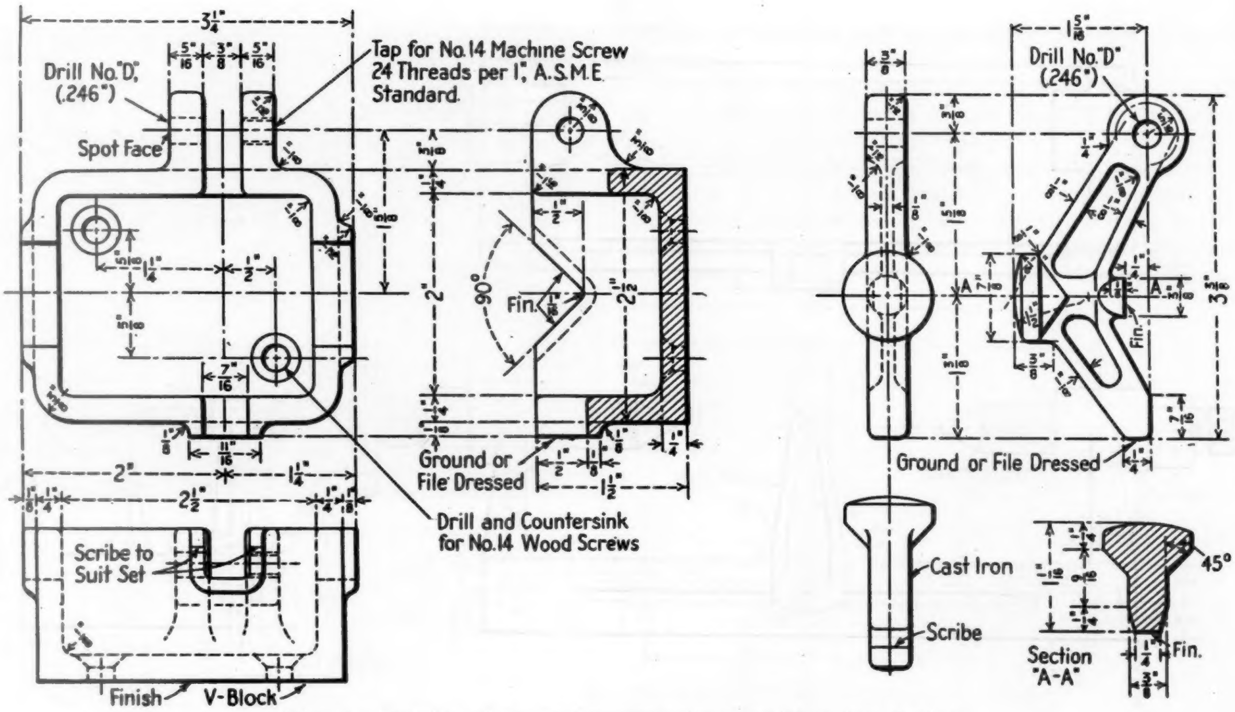


Fig. 5.—Details of an emergency-valve straightening device

ton head. A light tap with a hammer on the end of the bushing *C* is usually sufficient to correct the defect in the piston. In order accurately to gage this distance it is necessary to have the ring in the groove, which is the case with valves undergoing cleaning only, as the packing ring is not removed during this process. An inspection is also made of all threads and all castings are closely inspected for possible cracks.

Bent emergency valves are straightened with a device such as that shown in Fig. 5, and worn rubber seats are faced on a machine the details of which are shown in Fig. 6. Main triple valve pistons are tested on a device shown in Fig. 7, and straightened if necessary. Only such check valves as are found defective on visual inspection are ground. This operation is performed on a single spindle reciprocating grinder. Upon the completion of this inspection the parts are put in a tray and placed on the cleaning bench, adjacent to the inspection station. During the cleaning operation the valve parts do not lose their identity in relation to the valve from which removed, as the original parts are conveyed to the cleaning station.

When cleaning and lubricating a triple valve, neither kerosene, gasoline nor any other kind of mineral oil is used to clean rubber seats or gaskets, and all ports and passages are blown out with compressed air and inspected to make sure that any particles of dirt are removed. The internal parts of the valve, with the exception of the rubber seats and gaskets, are cleaned with a turpentine substitute.

During the cleaning operation the parts are blown off with air and wiped dry with cloth or waste. Care is

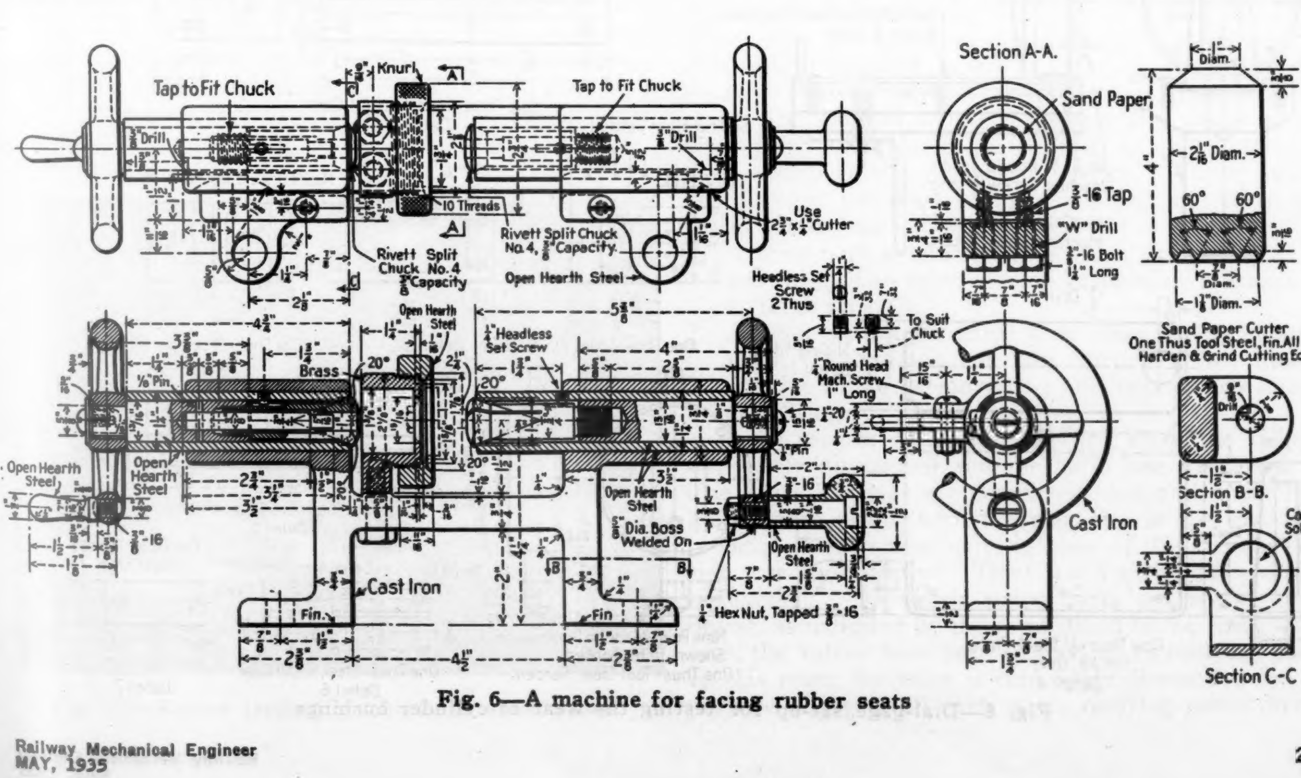


Fig. 6—A machine for facing rubber seats

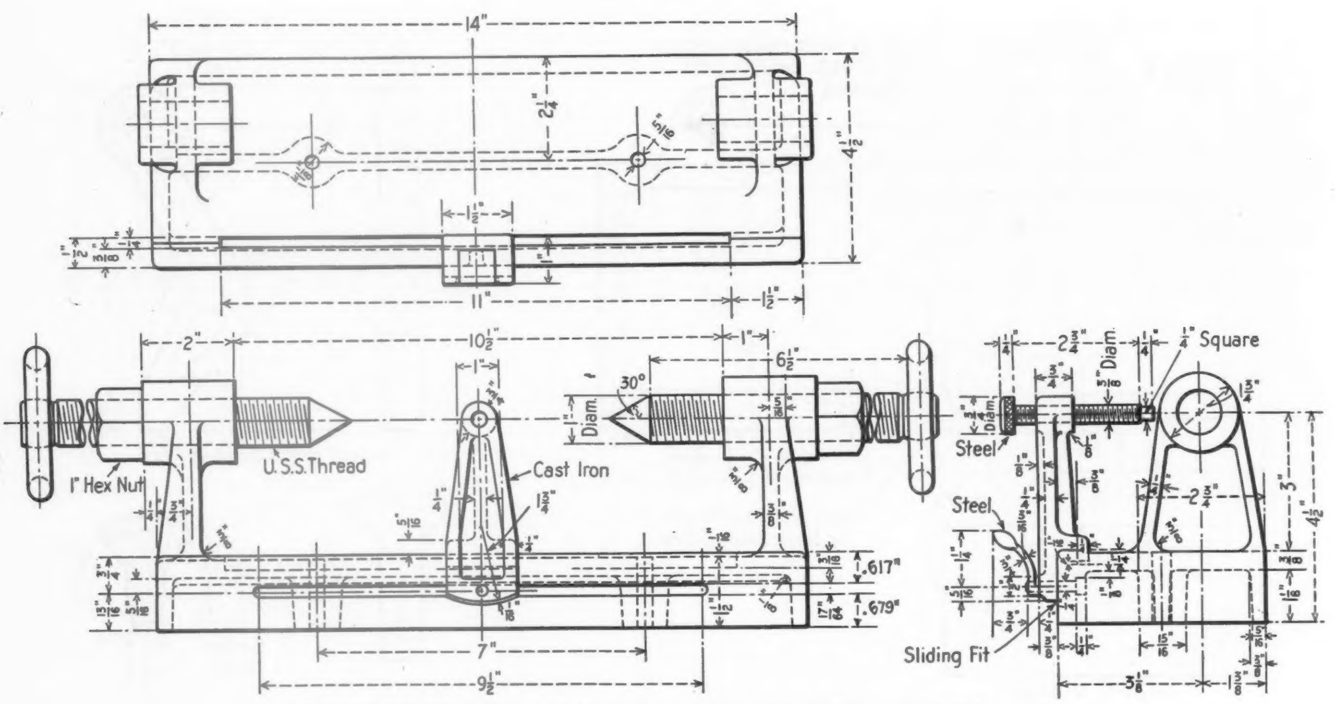


Fig. 7—Triple-valve pistons are centered by the use of this tool

taken to remove all oil or gummy deposits from the various parts. The seat and face of the slide valve and the slide valve graduating valve are lubricated with Triple Valve Dry Lubricating Graphite, the lubricant being rubbed on the surface of the slide valve seat and the upper portion of the bushing where the slide valve spring bears, so as to fill the pores of the metal but leave no loose graphite on the seat.

Triple valve parts which are lubricated with this lubricant are first made free from any oil or grease, and the graphite is rubbed in with a piece of chamois fastened on a small piece of wood. The triple-valve piston packing ring and its cylinder are lubricated with Marvin's Anti-Friction oil. Before the piston is placed in the valve body, one drop of this oil is applied to the ring groove, and the ring is turned through several complete revolutions. Then, after the piston has been placed in the valve body and moved to the release position one

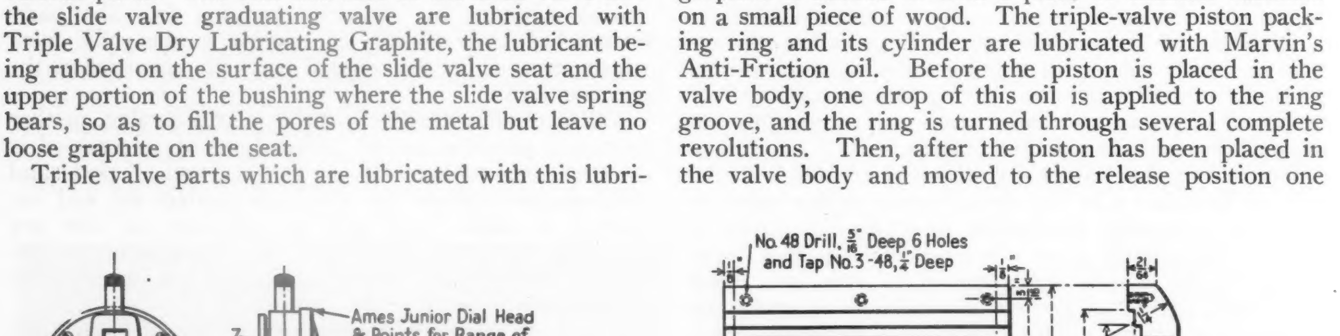


Fig. 8—Dial-gage set-up for testing the wear of cylinder bushings

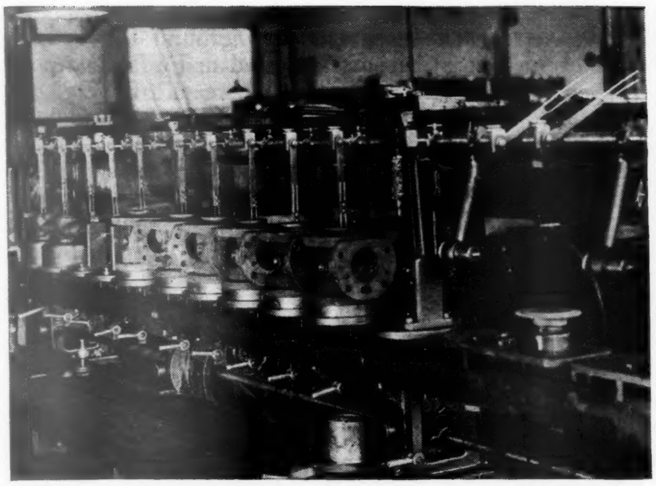


Fig. 9—Reciprocating lapping machine

drop of oil is applied to the circumference of the bushing, distributing the oil with the finger. The piston is moved back and forth several times and then any surplus oil is removed with a clean soft cloth. No lubricant is used on the quick action parts.

When cleaning and lubricating triple valves a pointed piece of wood similar to a lead pencil is used to loosen the piston packing ring in its groove, or to clean any of the feed grooves or ports. The use of a metal tool for this work is prohibited. Piston packing rings are not removed from the groove or distorted in any manner. All triple-valve pistons are tested on centers to insure their straightness. The graduating stem is carefully inspected to make sure that it works freely in the guide nut. The graduating spring and the retarded release spring must conform to standard dimensions and are carefully inspected to make sure that they are free of corrosion. The threaded portion of all cap screws, cap nuts and plugs are lightly coated with a graphite pipe joint compound before re-applying to triple valves.

After the triple valve has been cleaned it is assembled with the exception of the cylinder cap, which is left off for the purpose of enabling the test rack operator to apply a test device for checking the relation of the feed groove to the release port opening. The workman stamps his individual repair mark on the upper edge of the bolting flange, and places a special form in the check case. This form is numbered serially and, among other things, is used to aid in checking the day's output in the shop.

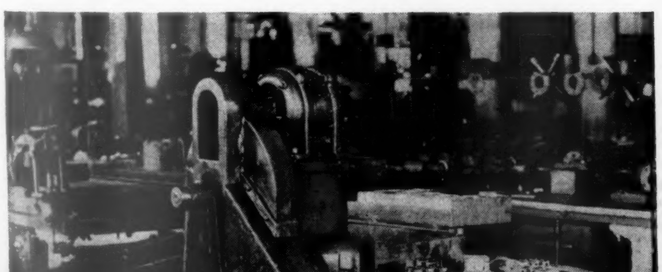


Fig. 10—Rotary lapping machine for slide valves

The tests on the standard test rack at Pitcairn are made in accordance with a prescribed code of the Association of American Railroads.

In the event the valve passes all tests the test rack operator places his individual identification stamp beside the cleaner's mark and places the valve on a ledge adjacent to the test rack where the openings are plugged and capped and a protector applied to the bolting flange.

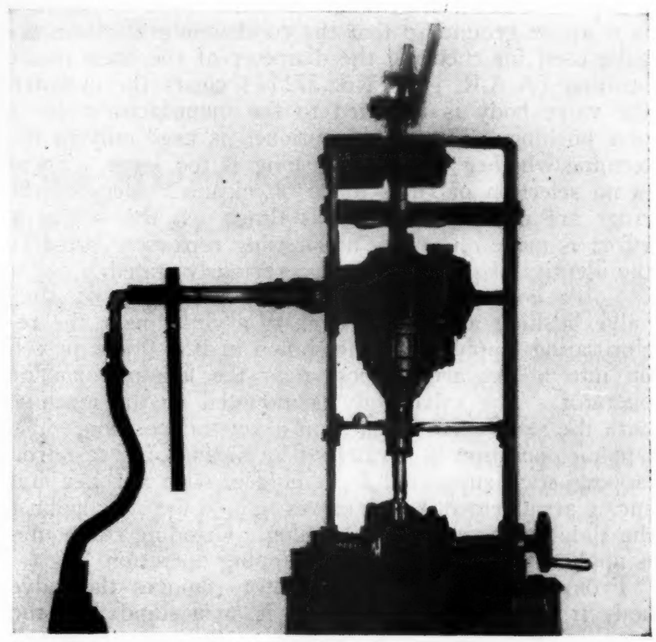


Fig. 11—Device for repairing exhaust port threads

The valve is then placed in a metal container and turned over to the store department.

Defective Valves

In the event that a valve fails to pass the test, the test rack operator records the defects on a special form and passes the valve in a tray down a roller conveyor to the dismantling machine, where it is again dismantled for repairs. Valves shipped in for repairs from outlying points are taken from the containers and placed at the same point as valves to be cleaned, as all valves must first pass over the dismantling bench. Valves which are destined for repairs can be divided into three different classes, as follows:

1. A valve with a defective slide valve, graduating valve and ring. This type, in shop vernacular, is known as a "three timer."
2. A valve with a defective slide valve and graduating valve. Shop men call this valve a "two timer."
3. A valve with a defective ring only is popularly known as a "ringer."

In the case of a valve of the first class, the valve is completely dismantled and the parts lose their identity. The Class 2 valves are completely dismantled but only the original piston with the ring left in the groove is replaced in the valve body, in view of the fact that the ring was not defective. The Class 3 valves are partially dismantled. The quick action parts are not removed unless, as indicated by the form found in the check valve case, the valves have been cleaned at an outlying point. In this event the valve is completely dismantled for the purpose of gaging all parts as the outlying points do not

have a full set of gages such as are used at the central repair shop. In any event, the form found in the check valve case designating the defects goes along in the tray with the valve down a shorter conveyor to the gaging bench. Only the repairs indicated are made unless the inspector finds other defects during the gaging process. The inspector does not duplicate the gaging on any valves previously gaged, such as those cleaned at the Pitcairn shop.

Piston bushings are gaged for wear with a cylinder bushing gage, such as that shown in Fig. 8. Any bushing worn .001 in. must be ground and when the bushing is worn or ground so that the condemning mark on the gage used for checking the diameter of the main piston bushing (A.A.R. gage No. 37114) clears the cylinder, the valve body is returned to the manufacturer for a new bushing. The gage mentioned is used only to determine whether or not a bushing is too large. There is no selection of rings made on cleaned valves as the rings are not renewed at this time. At this stage no effort is made on valves undergoing repairs to preserve the identity of parts except as previously stated.

Valve bodies which require the re-seating of slide valve bushing are passed over to a chute near the reciprocating lapping machine shown in Fig. 9 and passed on into a box arrangement near the lapping machine operator. The valve body is mounted on the machine with the slide valve bushing in a vertical position. The lapping operation is performed by means of a cast iron lapping stick supported by a holder, with a roller and spring arrangement which serves to hold the stick against the slide valve seat in the bushing. Grinding compound is applied to the stick for the lapping operation.

From time to time the operator removes the valve body from the machine, placing it on a stand with the bushing in a horizontal position. The seat is wiped clean and checked with a perfectly true parallel strip on which Prussian Blue has been lightly applied. When the valve seat has been properly ground the body is placed on a bench which is indicated in Fig. 2 at a point marked "triple valve bodies" within reach of the gaging inspector. Slide valves are also mounted by means of a holder on the reciprocating lapping machine for the purpose of lapping the graduating valve seat located on the upper side of the slide valve.

These valves are checked in a similar manner as the lapping process progresses. The slide valve face and the graduating valve face are lapped on a rotary lapping machine shown in Fig. 10. The gage inspector assembles sufficient parts on a tray to make up a triple valve, carefully checking all the parts. When selecting an emergency piston the clearance between the piston and its bushing is checked with a feeler gage allowing a tolerance from .008 in. to .012 in. with preference being given to the minimum tolerance.

Main pistons on which the ring groove is worn too large are returned to the manufacturer for closing and truing up the ring grooves, as are also emergency pistons which are condemned by the gage (A.A.R. gage No. 36958) used for checking the outside diameter. If the diameter is not too much under the condemning limit the piston is reclaimed by the manufacturer by swadging out and truing up the outer diameter. Check valve cases which require new bushings are returned to the manufacturer. Valve bodies in which the emergency piston bushings have been condemned are returned to the manufacturer for rebushing. Emergency valve seats which have been condemned by the gage which determines the proper height of the beaded seat (A.A.R. gage No. 36,961) or the diameter of the guide hole (A.A.R. gage No. 36,962) are reclaimed by building up by the oxy-acetylene process and machining to standard size. The flat face of this part is built up with a layer of 50-50 solder and machined. Slide valves which have been


THE PENNSYLVANIA RAILROAD
REPAIR TAG - PART 1
RETURN TO
SHIPPER WILL USE ONE TAG FOR EACH PIECE OF EQUIPMENT OR TOOL FORWARDED
SHOW ABOVE THE NAME AND DESTINATION TO WHICH ARTICLE WHEN REPAIRED IS TO BE RETURNED
REPAIR POINT WILL USE THIS PART OF TAG IN AN S.K. 7 ENVELOPE FOR RETURNING REPAIRED ARTICLE TO CONSIGNEE

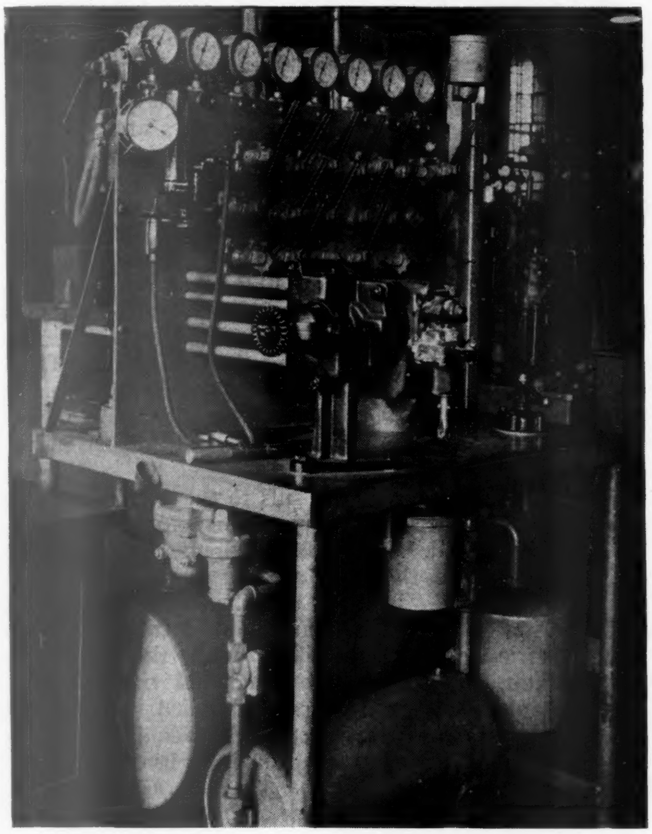
THE PENNSYLVANIA RAILROAD
REPAIR TAG - PART 2
FORWARD TO
SHIPPER WILL FOLD WITH PART ONE OF TAG ENCLOSE IN S.K. 7 ENVELOPE WITH FORWARDING ADDRESS SHOWING IN OPEN WINDOW AND ATTACH TO ARTICLE TO BE REPAIRED
SHOW ABOVE CONSIGNEE AND REPAIR POINT TO WHICH ARTICLE IS BEING FORWARDED FOR REPAIRS
REPAIR POINT WILL RETAIN THIS PART OF TAG AS RECORD OF REPAIRS MADE

REPAIR TAG - PART 1
ITEM FORWARDED
KIND | TYPE | SERIAL NUMBER | CAPACITY
DEFECTS OR REASONS FOR RETURNING EQUIPMENT OR TOOL
EXPENSE TO BE CHARGED
FROM
DIVN.
DATE 193
SIGNED
OVER
19-90-79

REPAIR TAG - PART 2
ITEM FORWARDED
KIND | TYPE | SERIAL NUMBER | CAPACITY
DEFECTS OR REASONS FOR RETURNING EQUIPMENT OR TOOL
EXPENSE TO BE CHARGED
FROM
DIVN.
DATE 193
APPROVED
SIGNED
TITLE
OVER
19-90-79

Repair tag used on the Pennsylvania for shipping parts to central shop—This is a reproduction of the actual tag attached to the first AB brake part to be received at Pitcairn for repairs

condemned for thickness or a shallow exhaust cavity are scrapped. Graduating valves which have been condemned for thickness are scrapped. Graduating stems which have been condemned by the gage used for checking the height of the stem above the gasket face (A.A.R. gage No. 36,963) are filed off to suit and the stems



Close-up of the AB test rack

which are condemned on account of being slightly short are reclaimed by facing the upper collar in order to allow the outer ends of the stem to project sufficiently to meet the gage. A large percentage of the retarding stems condemned by the gage used for checking these stems (A.A.R. gage No. 36,964) are reclaimed either by filing off the extension slightly or by taking a small amount off from the center projection in order to meet the gage.

Triple-valve bodies having broken exhaust ports are returned to the manufacturer for reclaiming by building up and restoring to standard dimensions. Bodies in which the exhaust port threads become worn are drilled and tapped out and rebushed to standard on a pneumatic drilling machine such as that shown in Fig. 11.

The gaging inspector, after assembling the parts for a complete valve on a tray, places the tray on a roller conveyor and it is carried to the repair benches. The repairman laps the piston ring on a face plate to fit the ring groove and after placing the ring in the groove laps the piston ring to a bearing in the bushing, using oil, which operation requires only a few strokes of the piston and ring back and forth in the bushing.

The slide and graduating valves are also lapped by means of a few strokes back and forth, using oil. The valve is assembled, with the exception of the cap, as previously explained, stamped with the repairman's identification mark and placed on a tray to be conveyed to the test rack at the left of the repair benches. Valves which pass the test are stamped by the test rack operator, plugged and capped, the protector applied and placed in containers for removal to the storehouses.

Pitcairn shop cleans an average of 1,910 and repairs an average of 1,050 triple valves each month.

Cleaning and Repairing AB Valves

Although the Pitcairn air brake repair shop is fully equipped for the cleaning and repairing of AB-type triple valves they are not as yet received in sufficient quantities to warrant an independent set-up as compared to the arrangement for handling the K-type triples. It is believed, however, that the same set-up will take care of the AB valves as well.

The Miner Coupler Lock Yoke

THE Miner coupler lock yoke, as illustrated, has been developed to replace wrought-iron yokes on cars equipped with 8½-in. and 9⅛-in. butt couplers without key slots. The device is made in two sizes in order to accommodate 18½-in. or 24⅝-in. draft gears.

This yoke is designed to meet all physical requirements of the A. R. A. key-connected yoke. The item of most importance, however, is the fact that this special yoke is readily interchangeable with the wrought-iron design, requiring no changes whatever in the coupler butt. It eliminates the use of rivets and, in doing so,

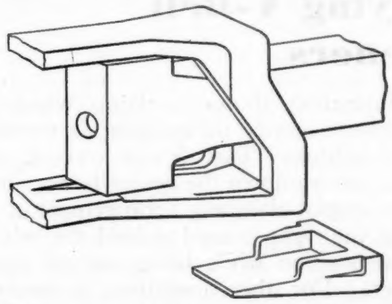


Fig. 1—Miner coupler lock yoke before assembly with the coupler

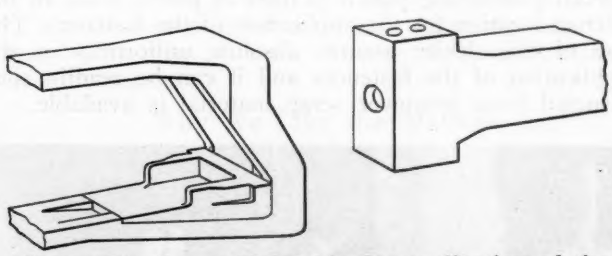


Fig. 2—Coupler applied ready for application of the lock casting

provides a flexible connection to the coupler. It is adaptable to either the 8½-in. or 9⅛-in. coupler butts, and the method of assembly is clearly illustrated.

The shouldered coupler butt, shown in Fig. 1, does not require burning, chipping or any other modifications before it is assembled to the yoke. The method of assembling the coupler is a simple process. The coupler is inserted into the front opening in the yoke to the position indicated in Fig. 2, the lock casting is then placed in its recess in the front end of the yoke and the coupler is pulled forward until the shoulders engage the two substantial abutments provided by the yoke casting

and coupler lock. The complete assembly of yoke, yoke lock and coupler is shown in Fig 3.

An important mechanical advantage, found in this design of yoke only, is the strength and flexibility of the connection. During all buffing shocks, the coupler moves rearwardly against the follower plate and transmits the load directly to the draft gear, permitting the yoke to remain stationary, while in most key-connected devices

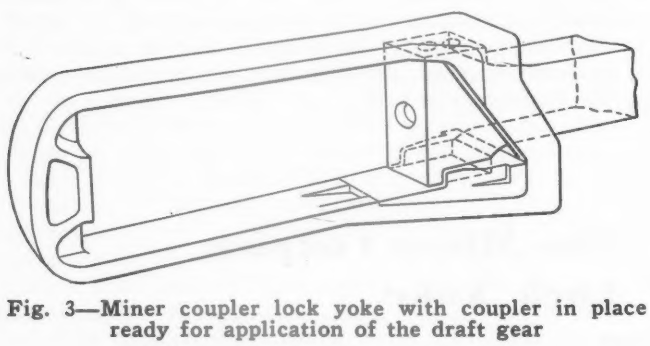


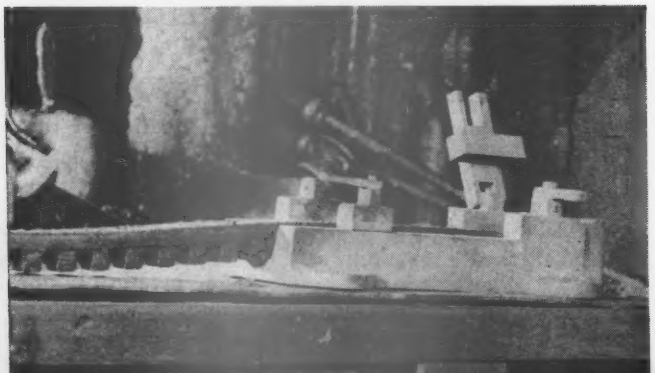
Fig. 3—Miner coupler lock yoke with coupler in place ready for application of the draft gear

the damaging blows are transmitted through the connecting means to the yoke casting, thereby causing considerable wear and damage to this most important member.

The yokes are produced of special heat-treated steel which makes them unusually tough and wear-resistant.

Applying V-Belt Fasteners

THE illustration shows a clamp which has given satisfactory service in applying fasteners to Rodewald-type V-belting. This device consists of a metal frame with a groove down the center to accommodate the V-belt and a special clamping arrangement at either end. The clamp at the right is used to hold the belt firmly and accurately in position while being cut off square at the desired point. For this operation, a special knife is used, being operated in a guide groove. The belt is then shifted to the clamp position at the left where a special positioning punch is used to punch holes in the correct location for the application of the fasteners. The use of this device assures absolute uniformity in the application of the fasteners and it can be readily constructed from whatever scrap material is available.



Device used in applying fasteners to Rodewald V-type belting

Reconditioned Caboose Cars

(*Continued from page 198*)

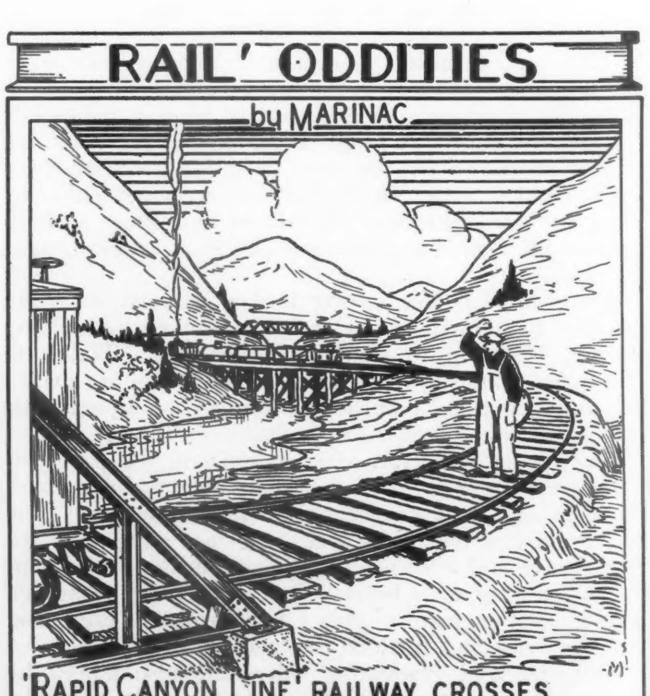
two coats of plastic car cement. All window sash, doors, seats, etc., are thoroughly repaired in the cabinet shop and upholstery shop before being replaced in the cars.

Application of the Z-Bar Center Sills

The detailed labor and material costs in applying the Z-section center sills and associated parts are shown in the table. When the sills are received at the erecting shop, they are placed on two push cars on a track equipped with an overhead air hoist. The sill ends are blocked the proper distance apart and the sills lined up, straightened and clamped at the top. Metal strips are temporarily spotwelded across the bottom to maintain the correct alinement and spacing. Supporting jacks are placed at the middle of the Z-sections and screwed up until the middle is 1½ in. higher than the ends. Then, after welding operation which joins the two Z-sections is completed, the jack removed and the sills cooled, they will be straight, no camber being provided in the finished car.

Bolt holes for securing the sills to the car bodies, also rivet holes for draft lugs, carrier arms, etc., are laid out, burned and reamed. Slots are cut for the top leaf of the body transom and the ends are cut to receive I-beam platform end sills. The sills are then turned over and body bolster filler castings are applied, these castings being electric-welded to the sills. While the sills are in this position, lug castings are fitted and riveted to the sills. Couplers and draft gears are applied. Pocket and coupler carrier irons are fitted and riveted. The sills are placed under the caboose, jacked in place and bolted.

* * *



Further explanation furnished by the editor upon request

In the
Back Shop and Enginehouse

Roundhouse Foreman's Daily Log

Is He Getting a Square Deal?

[Editor's Note: The enginehouse foreman, working on long shifts and in most instances under heavy pressure, has no sinecure. The loyal, painstaking service these men are giving is worthy of sincere commendation—and also of critical study and attention to see whether they can be given a better break. The following article is not a story, or a piece of fiction. It is a simple recital of a day's, or rather, a night's experience. As a matter of fact it is lifted, except for the subheads, from a letter which came to my desk a few days ago.]

And So the Work-Day Begins

Two of the three day foremen are seated at their desks, when I arrive at 6:45 p. m. Their greetings are glum and their attitude bespeaks dejection, if nothing worse. Some years ago I used to visit my father in the roundhouse foreman's office at every opportunity, because of the jovial spirit encountered there. The conversation was filled with banter and jocularities. The hours at that time were the same, but the pressure of providing power for the railroad's movements was not so great as to squeeze out the men's natural enjoyment of their work and eliminate their sense of humor. Now the conversation is monosyllabic and rather on the grim side.

The third day foreman is still down in the house. He has charge of the westbound freight engines and there is a quarterly inspection to finish on one of them by 9:15; he won't leave until he is sure that there is a fair chance of making it. In case of a tight squeeze like this, it is customary for the man in charge to stay until it is made or lost.

Who Is Johnson?

Now for the eastbound. There are eight freights to go between now and midnight. Three are called now—7:15, 7:45 and 8:15. According to the turnover book we have eight east end engines here, so if all of them are in reasonably serviceable condition—they are maintained at the other end of the line—the east end situation is fairly satisfactory. The first two are O.K.; the third is being worked by—wait a minute—by a machinist named Johnson. Last night I had no one of that name. It appears that the back shop has been closed for the remainder of the month. Mr. Johnson has exercised his seniority and displaced one of my four regular men.

But that isn't all—another shop man has displaced my other east end man. Things are beginning to look worse a little earlier than usual tonight! I have six engines to work between now and midnight, with two men that are for running repair purposes almost totally useless. I've machinists in their place. No one in the shop can repair a distributing valve any more efficiently than Johnson, but we have only one on each engine and they are, regrettably, in good shape; besides we have a good air man. What I need is the man who can do the most work that is vital to the condition of the engine in the short time that we can allot to it. This sort of thing happens when the shop closes every month—and worse than that, after one dose of roundhouse medicine the shop man usually prefers the layoff, so we have a new set of novices every time.

Pinch-Hitting for the Errand Boy!

With a mental note to keep at least one eye on those two men I go down to see if I can help the west end foreman with the 9:15 engine. Maybe he'll turn the reins over to me and go home as he should, but I doubt it. He has both of the west end men on the engine. Valve motion to assemble, side and main rods to go up—rather a sad looking mess, but if everything goes right those two remaining old heads can make it. Will I go over to the shop and see if I can hurry up those bushings? I certainly will—and do! The one machine man who has been retained during the shutdown period has most of the brass ready, but there are no castings from which to make knuckle bushings. Some one has to go to the store after three of them. The machine man can't waste thirty or forty-five minutes of his time poking around the brass room. We have no laborers. Who goes? Right—the roundhouse foreman!

When I return to the roundhouse, it is second shift lunch period. The hostler has set that 8:15 east-ender out. I pick up the reports from the case in front of the stall. What's this? An item on the inspector's report, "Middle wrist pin nut broken," not signed for. A run for the engine, to take a look. Broken it is! Almost half of it gone—the cotter key holds the other half on. Who worked, or didn't work the engine? Oh, yes, one of the novices. Eating lunch over in the shop, probably. Back I go—the first race with time is now on. The engine should be on its way to the yard at 8:35. When I find Johnson we have 12 minutes to go. I find a new nut for him—we pick up tools on the way past his box and, Lord help us, I have to show him how to crawl between the frames to change the nut. We lose this race by 10 min. Another delay to explain in the morning.

Why We Like the Mallets

Now back to that 9:15 west-ender. The day man has by now seen the successful end of his efforts near, so he has finally gone home. Only 14 hours for him today. I take one of the machinists and his helper to start on a Mallet. I might need it to protect this big engine, or if not, there is a westbound drag to follow this manifest immediately. The transportation department doesn't like Mallets. They are slow, but dependable, and usually require but little work and having one ready, or nearly so, frequently saves a serious delay—so *we* still like them.

To the office now to see about the west end. A phone conversation with the chief dispatcher. He will need eight engines—two for drags, six for manifests—at 2:30, 3:30, 5:00, 6:30, 8:00 and 9:00 a.m.—the drags before that, if possible. I check up. Of the engines in the house there are two Mallets and two 900's not tied up. One of the Mallets is ordinarily used on the west local at 8:30 a.m., but there are two more coming over before

then, so I O.K. the drags for 11:00 p.m. and 12:30 a.m. Those two big engines in the house are in fair shape—they'll go! There are four more at the chute and three due in. The engineer's reports on the ones that are in don't look bad, but one is due for a monthly inspection—that's out. One of the three coming in has just about reached its limit on flues, so can't be counted on. However, though it is too early to be positive about it—anything can happen in the roundhouse, and sometimes does—the west-end looks at least favorable.

One of the Few Joys

Back down to the house. The 9:15 engine is leaving. The boys who finished it are really all right. The way they made a locomotive out of the parts on the floor is one of the few joys that come to a foreman. The man that I left here has already, without instruction, moved to the engine marked up on the board for the next manifest.

Now for a few minutes with those east-end men. Another predicament, a mild one, has developed. In checking the middle main rod on the engine due to go at 11:30, the machinist found a broken brass. At best five hours are required to renew it and we have only two hours to get an engine. Obviously we must do something else. This time the alternative is fairly simple. All we have to do is to go out to the chute and switch seven or eight assorted passenger and freight engines around to get an east-ender up to the ash pit, get a hurry-up job of fire knocking done, rush it in the house, change the water in the boiler, fire it up, and it is ready to go again.

More Complications

This action disrupts the meager coal chute forces, resulting in delaying the arrival in the house of the west end freight and passenger power, which in its turn necessitates a little personal pushing on the third-shift boiler washers, boilermaker and firelighter in order to make up the time lost. My own part in this little rush act is not small. To expedite matters I help knock the fire, rather than waste precious minutes chasing the inside hostler. I take the engine in the house. The boilermaker is somewhere else, so I hook up the blow down pipes, go in the firebox to look it over, then coal it up with the stoker while there is still steam, then rearrange the schedule to make this engine the last one out, thereby gaining a much needed hour.

There is, I believe, small point in continuing this blow-by-blow account through the remaining eight hours. On the engines assigned to this point it is necessary to decide how much of the necessary maintenance work can be done. There will be, before morning, four or more minor emergencies to be met. More miles to cover, more physical exertion. I have been told that a large part of good supervision consists of judicious delegation of duties to capable individuals, but when running a roundhouse with a minimum force, it usually happens that all individuals, capable or otherwise, are busy, so that any extra duties are delegated by the foreman to himself. Most nights are not long enough for him to discharge them all. The job resolves itself into a continuous battle with disturbing elements.

Punch-Drunk From Battling

Most men enjoy a battle, but after months of 12-hour rounds night after night, they are liable to become slightly "punch-drunk." This is particularly true when they can't be sure of having won. Getting engines to the yard is the smallest part of the job. They will be on the road from four to thirty-six hours after leaving the terminal and their performance during that time depends almost entirely upon the condition into which the roundhouse forces have been able to get them during their brief period in the terminal.

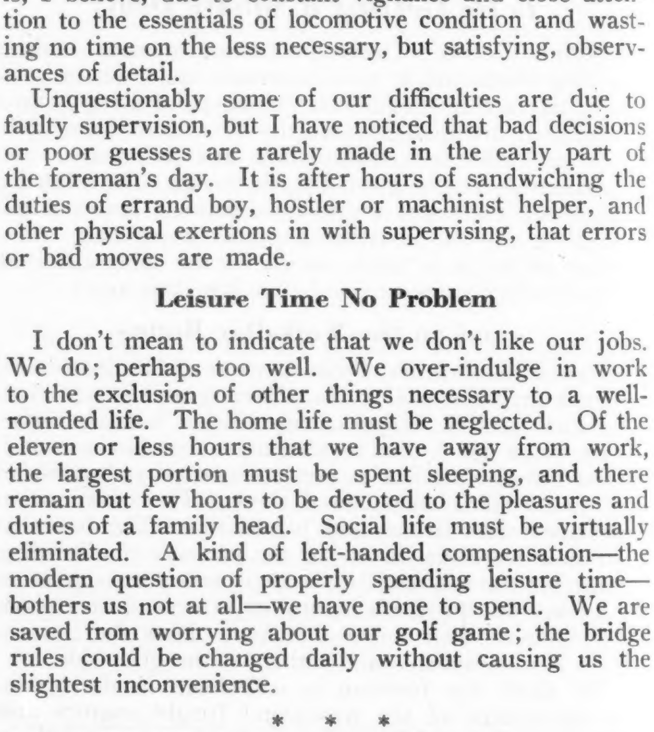
The supervisors are craftsmen, and would take greatest pleasure in delivering perfect engines for service. That pleasure is usually denied them and too often conditions require that engines be put into service that come closer to being imperfect than perfect. As a result, the men work under the strain and fear of that awful word "Failure," and its consequences. Our record here is good in that respect. Serious failures are rare and that is, I believe, due to constant vigilance and close attention to the essentials of locomotive condition and wasting no time on the less necessary, but satisfying, observances of detail.

Unquestionably some of our difficulties are due to faulty supervision, but I have noticed that bad decisions or poor guesses are rarely made in the early part of the foreman's day. It is after hours of sandwiching the duties of errand boy, hostler or machinist helper, and other physical exertions in with supervising, that errors or bad moves are made.

Leisure Time No Problem

I don't mean to indicate that we don't like our jobs. We do; perhaps too well. We over-indulge in work to the exclusion of other things necessary to a well-rounded life. The home life must be neglected. Of the eleven or less hours that we have away from work, the largest portion must be spent sleeping, and there remain but few hours to be devoted to the pleasures and duties of a family head. Social life must be virtually eliminated. A kind of left-handed compensation—the modern question of properly spending leisure time—bothers us not at all—we have none to spend. We are saved from worrying about our golf game; the bridge rules could be changed daily without causing us the slightest inconvenience.

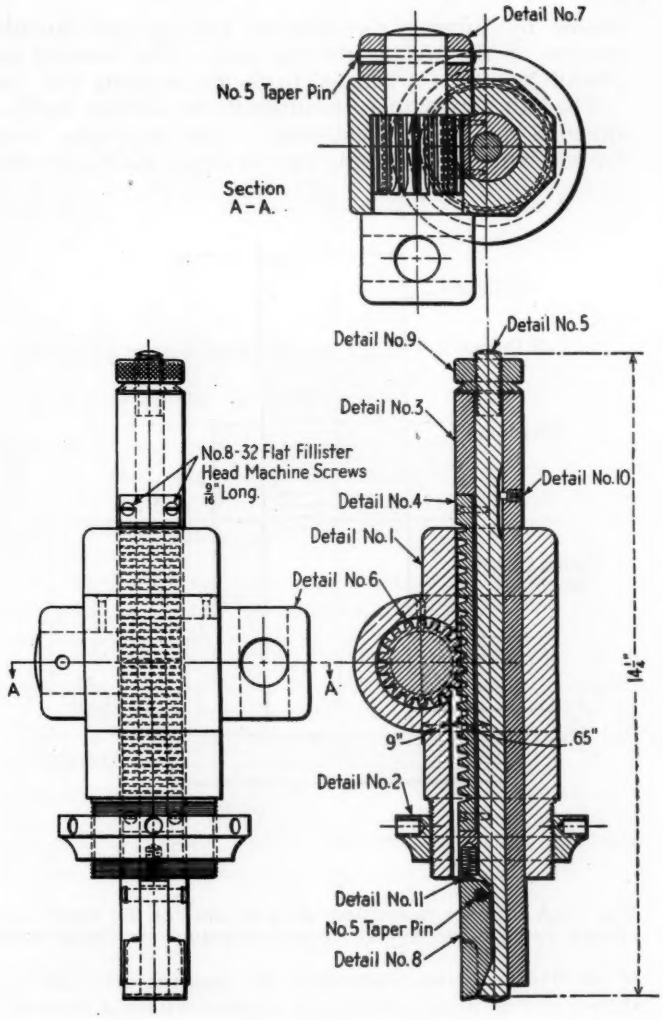
* * *



Further explanation furnished by the editor upon request

Special Tools Used in Air-Pump Work

IN the article describing the methods used for repairing air compressors at the Pitcairn (Pa.) air-brake repair shop of the Pennsylvania, which appeared on page 157 of last month's issue of the *Railway Mechanical Engineer* reference was made to three special tools developed for use in connection with repair operations. One of these tools mentioned was a broaching tool designed for truing up the seat in the reversing-valve bushing of the 8½-in. cross-compound air compressor without the necessity of removing the bushing from the top head. It is the practice in some shops to remove these bushings in order to true up the seat, but it quite often happens that the bushing is damaged in the process of removal. A tool of this type makes it possible, at considerable saving of labor and material, to true up the seats with the bushings in the head. The design of this reversing-valve-bushing seat broaching machine is clearly shown in the drawings Figs. 1 and 2—Fig. 1 being an assembly of the machine and Fig. 2 the constructional details. As may be seen from Fig. 1 the machine is mounted on the head in the threaded opening from which the reversing-valve-chamber cap has been removed and is secured by a lock nut, shown in Fig. 1 as detail No. 2, which is set in place by the use of a spanner wrench. The tool holder, shown as detail No. 3, operates in the guide (detail No. 1) and the broaching tool is actuated by a pinion and rack, the pinion being operated by hand power. Through the center of the tool holder there is a rod threaded at its upper end and embodying a tapered portion at the lower end. The cutting tool, shown as detail No. 8, is of the high-speed-steel insert type and the tool is fed into the work by the movement of the rod shown as detail No. 5 which is



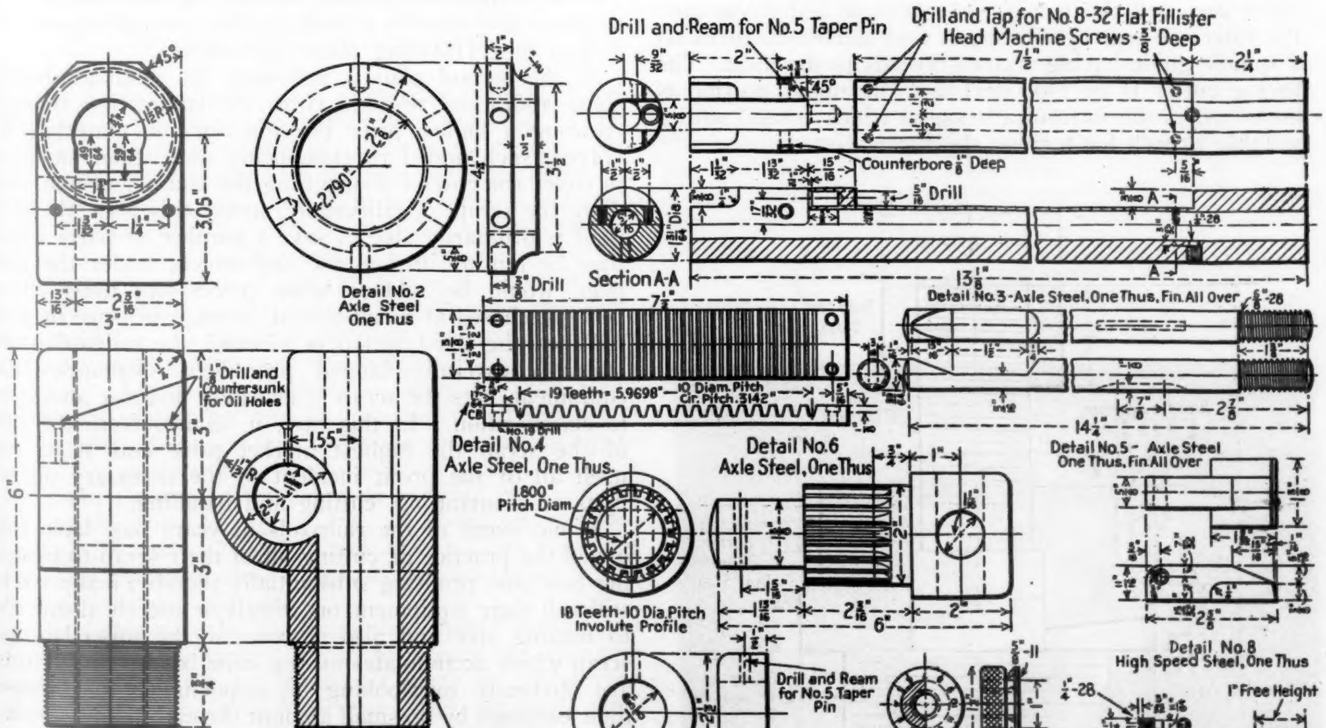


Fig. 1—(above) Assembly and details (Fig. 2—below) of a machine for broaching reversing - valve - bushing seats

caused by turning the knurled nut on the threaded portion of the rod at the top end. The knurled nut (detail No. 9) is graduated to facilitate setting the tool.

The other two tools mentioned are similar in type, although for different purposes. One is a special tool for re-seating the cap seat for the upper discharge valve

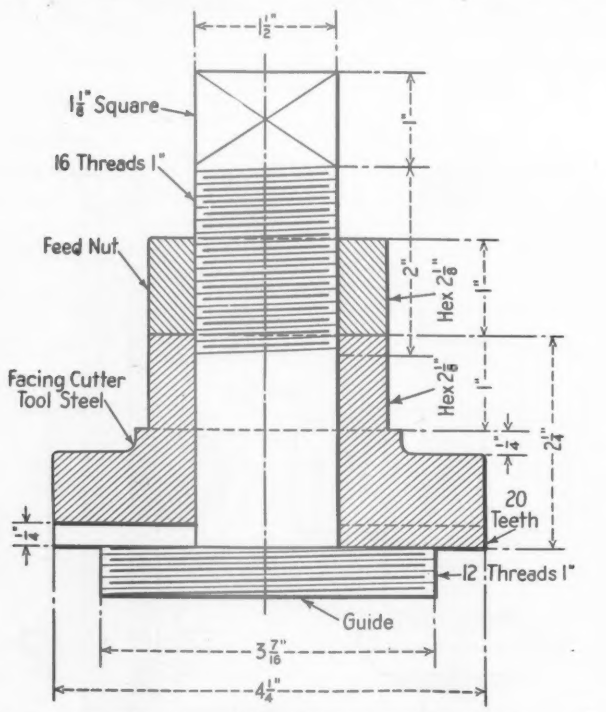


Fig. 3—A tool for re-seating the cap seat for the upper discharge valve of an 8½-in. cross-compound air compressor

of an 8½-in. cross-compound air compressor. This is shown in Fig. 3 and consists of a guide which is threaded to fit into the threaded opening for the upper discharge valve cap, and the facing tool which is fed down onto the valve-cap seat by a hexagon feed nut which turns on a spindle guide having sixteen threads to the inch. The facing cutter is of tool steel and the upper portion is milled off in the form of a hexagon which is used with a suitable wrench for turning the facing cutter.

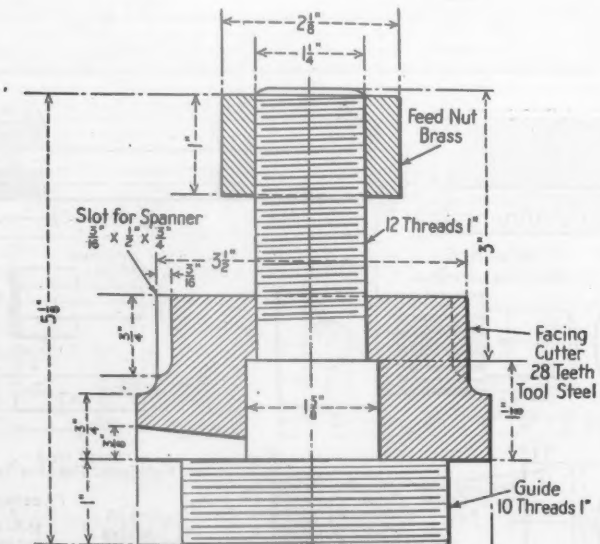


Fig. 4—This tool is used for re-seating stuffing box joints in the center casting

The third tool, shown in Fig. 4, is used for re-seating the stuffing-box joint in the center casting. The tool consists of a guide, facing cutter and feed nut. The guide has two threaded portions, the lower one having threads to suit the stuffing-box threaded opening in the pump center casting, while the upper end of the guide is threaded with twelve threads to the inch for the feed nut. The facing cutter, which is made of tool steel with 28 cutting teeth, is fed into the work by the hexagon nut. Slots for a 3/16-in. by ½-in. by ¾-in. spanner are milled in the facing cutter.

Maximum Profits from Scrapping Equipment

During the past few years, the railroads of the United States have dismantled and sold as scrap thousands of locomotives and tens of thousands of freight cars. During the coming years, particularly with a return to normal traffic volume, they will scrap other thousands of units of equipment which, due to age and design, do not fit into modern transportation.

The disposal of these locomotives and cars in the most advantageous way presents a problem to the railroad management. When a number of units of equipment are to be disposed of, the choice of three procedures is presented. The equipment can be sold on its wheels to the scrap dealer; it may be dismantled by the railroad and the materials reduced to convenient loading size; or all of the materials contained may be cut to charging box size and sorted to grades, as required by the ultimate consumer, the steel mill.

If the first option is selected, it is obvious that the amount received for the equipment will represent a price per ton which will permit the buyer to pay the cost of dismantling, cutting to charging box size, sorting to grade and provide a profit to him over all expense involved in performing these operations.

If the second plan is followed, the railroad derives some additional revenue from the transaction through securing a higher price per ton for the materials involved, such added revenue being more than sufficient to cover the cost of dismantling the equipment and handling the scrap. Additionally, under this plan, the railroad is ordinarily able to save a number of parts which may be put to further use and which, under the first plan, would be sold at scrap prices and must either be repurchased at a substantial increase in price or lost.

When the third option is adopted, the railroad itself, under a carefully-planned procedure, dismantles the equipment, cuts the scrap to charging box size and sorts to classification. In this case, it secures from the sale of the scrap the highest market price and saves for itself all of the profit incident to the necessary operations of dismantling, cutting and handling.

While many of the railroads in years past have followed the practice of cutting all of their scrap to charging box size, profiting substantially thereby, many roads still sell their equipment on wheels or merely dismantle to loading size and also dispose of the miscellaneous scrap which accumulates on the same basis. Such roads are obviously overlooking an opportunity to increase their earnings by no small amount through taking advantage of the differential which always exists between the price of miscellaneous scrap materials and the price of the same materials when properly cut and graded.

A recent study on one of the railroads indicates just how much may be realized by cutting locomotives to

steel mill classification instead of selling them on wheels or disposing of the material in loading size. The following figures show the results of a carefully-conducted test designed to determine the most profitable method of handling a locomotive scrapping program:

Profit Resulting from Cutting 100-Ton Locomotive and Tender to Charging Box Size

	Selling price per g.t.	Cost of preparing scrap per g.t.	Net price to railroads per g.t.	Net profit to railroad on 100-ton locomotive
On wheels	$7.28	$....	$7.28	$.....
Loading size	9.22	1.33	7.89	61.00
Charging box size	11.63	2.43	9.20	192.00

Due to constant fluctuations of the scrap market and to the variations obtaining in different sections of the country, the figures given would, of course, apply only

Typical example of an obsolete steam locomotive being cut up by the oxy-acetylene method in such a way that the railroad can realize maximum returns from the scrap

at a particular time and in a particular locality. However, while the scrap market varies from day to day and from place to place, the differential between cut and uncut scrap remains fairly constant and, while the profit in dollars would vary from time to time and from road to road, the percentage of profit secured by reducing scrap to charging box size remains constant.

The expense involved in cutting, sorting and handling the scrap will, of course, depend largely upon the facilities available. Very few railroads, however, are not fully equipped to take care of this work in an economical manner. All that is required is shop or yard room where the equipment can be dismantled without interfering with other operations; oxy-acetylene cutting equipment for performing the dismantling operations in a minimum time and at the lowest possible cost and for cutting the parts to proper size; a locomotive crane for loading the materials and, if available, a large shear for reducing the light sheets such as are contained in the tank to charging box size.

The locomotive to be dismantled should be laid out for the cutters in such a way as to require the minimum amount of cutting to reduce all parts to the desired dimensions. The best procedure after stripping pipes and appurtenances is to start the oxy-acetylene cutters on top of the boiler. These men can then cut their way down toward the rails with the minimum amount of lost time and with the least possible handling of materials. Very little crane service is required during the cutting operation when this procedure is followed. After the locomotive has been reduced to charging box material, the crane crew can classify the material as it is loaded, thereby avoiding any additional handling.

This method of handling locomotive scrapping has been in use on some of the railroads for a number of years and its general adoption by all of the roads would bring profits to them of which they are at present in great need.

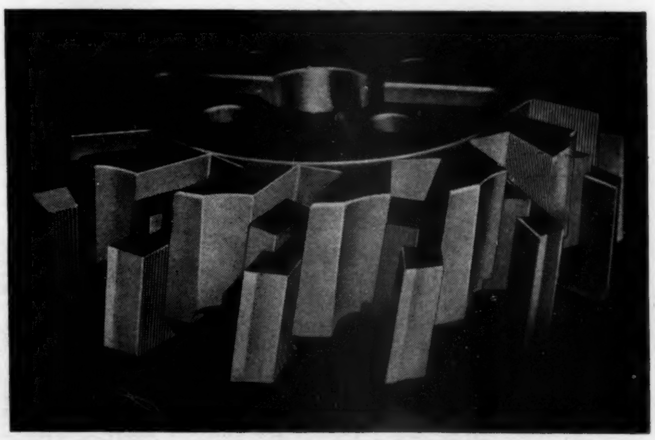
Milling Cutters with Zee-Lock Faces

THE Ingersoll Milling Machine Company, Rockford, Ill., has designed a new type of inserted milling cutter having blades with a zee lock. The cutters are positively locked and doubly adjustable, principally in the direction of major wear.

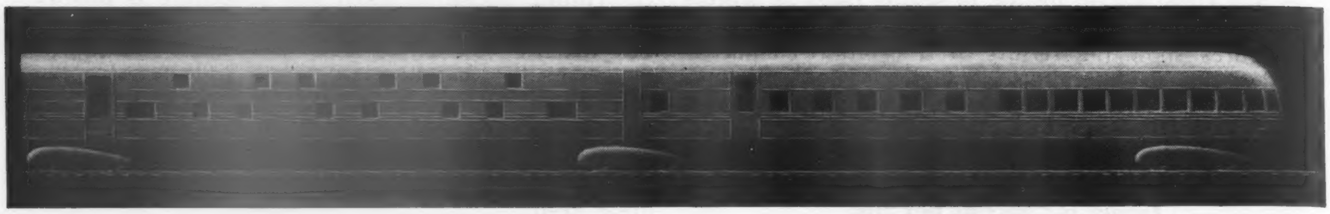
As shown in the close-up illustration, the Ingersoll zee lock cutter blade is securely retained in the cutter housing by a zee shaped wedge, which hooks over the front of the cutter body and the back of the blade. It is impossible for the blade to shift backwards or inwards away from the cut. The back hook of the wedge is on a slant so that when the cutter blade is reinserted and moved out a serration it also moves forward a slight amount, thus compensating for the slight amount of face wear. The main adjustment, however, is outwardly or radially as a cutter always wears most in the direction of feed. No additional parts are required for resetting —the blade adjusts itself automatically in the proper proportional directions of wear. The wedge is the locking member and is not disturbed by the thrust of the cut as this is absorbed by the serrations. The serrations further increase the area of contact for locking.

This arrangement may be applied to many kinds of cutting tools. Medium duty cutters, using a blade 3/8 in. thick with a blade spacing of about 1 in., are used for medium duty or finishing operations; heavy duty cutters with a blade spacing of 1½ in. to 1¾ in. using blades ½ in. thick, for general purpose cutter, and for the heaviest milling operations an extra heavy duty cutter, with blades ¾ in. thick, spaced about 3 in. apart. Cutter bodies are made either with the National Standard planer or flange nose drive, or to fit any special machine.

The cutter housings are of forged and heat-treated chrome molybdenum alloy steel while the milling blades are made of special steels to meet varying requirements.



Close-up view of Ingersoll milling cutter with zee-lock blades



NEWS

Patterson Urges Elimination of Arch-Bar Trucks

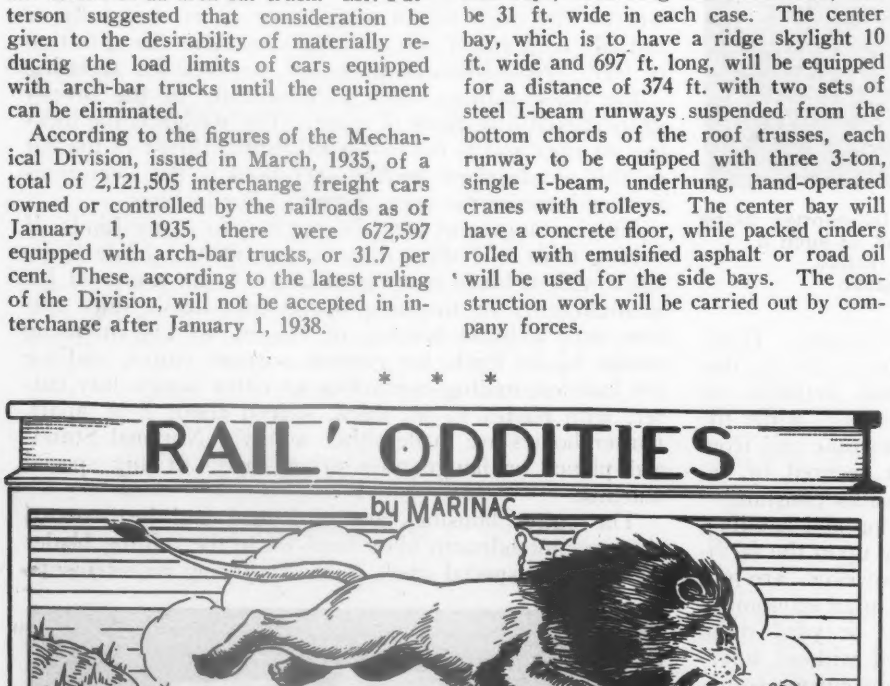
A SUGGESTION that further consideration be given to the use of arch-bar trucks and that measures be taken to eliminate them from service at the earliest possible date is included in a report by W. J. Patterson, director of the Bureau of Safety of the Interstate Commerce Commission, on the derailment of a freight train on the Missouri Pacific on February 25, caused by the failure of an arch-bar truck. Mr. Patterson suggested that consideration be given to the desirability of materially reducing the load limits of cars equipped with arch-bar trucks until the equipment can be eliminated.

According to the figures of the Mechanical Division, issued in March, 1935, of a total of 2,121,505 interchange freight cars owned or controlled by the railroads as of January 1, 1935, there were 672,597 equipped with arch-bar trucks, or 31.7 per cent. These, according to the latest ruling of the Division, will not be accepted in interchange after January 1, 1938.

Northern Pacific To Rebuild Car Shed at South Tacoma

THE Northern Pacific has undertaken the reconstruction of a freight car-repair shed at South Tacoma, Wash., which was destroyed by fire in November, 1934. The new shed, which will be of the open-type and of timber construction, will cover four tracks and will be 106 ft. wide by 732 ft. long. The center bay, containing two tracks, will be 44 ft. wide, while the outside bays, containing one track each, will be 31 ft. wide in each case. The center bay, which is to have a ridge skylight 10 ft. wide and 697 ft. long, will be equipped for a distance of 374 ft. with two sets of steel I-beam runways suspended from the bottom chords of the roof trusses, each runway to be equipped with three 3-ton, single I-beam, underhung, hand-operated cranes with trolleys. The center bay will have a concrete floor, while packed cinders rolled with emulsified asphalt or road oil will be used for the side bays. The construction work will be carried out by company forces.

* * *



Further explanation furnished by the editor upon request

Two-Car Articulated Streamlined Units To Tour Country

BEGINNING next autumn two two-car, articulated, streamlined passenger units of the type illustrated will be operated by the Pullman Company on the rear of trains of standard equipment to demonstrate high-speed, light-weight equipment. These two units, which will be moved over the country from one road to another and which will enable railroad men to study streamlined equipment in regular service, are now under construction in the shops of the Pullman-Standard Car Manufacturing Company, Chicago. The structural frame and outside plates of the cars will be light-weight steel alloy, and the interior finish and fittings will be of aluminum. The construction will be similar to that which has been adopted for the new Illinois Central Chicago-St. Louis train now being built at the Pullman works. The width of these units will be Pullman standard—that is, 9 ft. 1 in. inside—while the length will be 64 ft. between truck centers. This does not include the overhang at each end, which in the case of the lounge rear of the second car amounts to 11 ft. 7 in. The cars will be articulated and will have one truck under the adjoining ends of the two car bodies, or three trucks in all.

The head car of the unit will be of the "Duplex" type, containing 15 single bedrooms, 8 of which are "upstairs" and the remainder on the floor level, or "downstairs." These will be of regular bedroom type, the transverse bed forming a sofa by day. Each room will have individual lighting, heating and toilet facilities. The cars will be air-conditioned, the latter comfort being an adaptation of the Pullman-Standard system. The head section will have a vestibule to co-ordinate with that on the rear of the standard sleeper to which it will be attached.

The rear section will contain rooms, a buffet and a lounge, the latter extending to the rounded end, first introduced in the Pullman-built Union Pacific streamline trains. The forward half of the car will accommodate four double bedrooms, one of which will have longitufinal beds, a lower and upper. The buffet will serve light refreshments, having about the same capacity as that in the "George M. Pullman." The lounge forming the remainder of the car—practically one-half—will seat 26 persons.

The lighting of both cars will be both direct and indirect. The furniture will be designed for comfort and harmony with the decorative treatment of car interiors.

U. P. Renovating Passenger Cars

THE Union Pacific is air-conditioning 40 coaches and chair cars for main-line

passenger service as part of its program for improving passenger service. The cars will be completely renovated and redecorated, and the seats will be upholstered. A porter will be assigned to each to give coach and chair-car passengers the same character of attention provided in other cars. The new porters will have uniforms of blue and gray.

New Course at N. Y. U. on Principles of Train Streamlining

A NEW course on the basic aerodynamic and dynamic principles of streamline trains and other high-speed railroad equipment will be inaugurated this fall at the Daniel Guggenheim School of Aeronautics in the College of Engineering at New York University. The course will be in the charge of Professor Alexander Klemin, director of the school, who explained in his announcement that it will be one of a group of courses that will lead to the degree of Master of Science in Aeronautical Engineering. In giving the reasons for the inauguration of the course, Professor Klemin referred to the fact that a number of graduates from the aeronautical school have found employment as specialists in the design and construction of high-speed trains and locomotives.

Professor Klemin has developed special wind-tunnel equipment for testing air resistance of high-speed locomotives, automobiles and other vehicles which run on the ground, and the laboratory work in the new course will center around this equipment. He explained that the Guggenheim School, with models supplied by the American Car & Foundry Company, the American Locomotive Company and the Union Pacific, has probably "done as much work on the aerodynamics of trains and locomotives as has been done in any laboratory in the world." He further said that there has been developed in the school special equipment whereby "for the first time models 22 ft. in length have been tested, and we have developed an entirely new form of apparatus for the wind-tunnel testing of trains and automobiles."

Professor Klemin said that the new course will run through the whole school year and will be followed by problems and experiments in the aerodynamic laboratory. The actual instruction will be given by specialists in railroad work under Professor Klemin's direction.

New Equipment

Car Orders

Purchaser	No. of cars	Type of car	Builder
Amtorg Trading Corp.	5,000 sets	Wheels and axles for freight cars	Bethlehem Steel Co. and United States Steel Corp.
C. B. & Q.	500[1]	50-ton composite gondolas	Company shops
Erie	55	40-ton milk-car bodies	Greenville Steel Car Co.
Fisher Body Corp.	100	50-ton box	Merchants Despatch
New York Rapid Transit Co. (B. M. T.)	25[2]	25 5-section articulated train units	Pullman-Standard Car Mfg. Co. (15) St. Louis Car Co. (10)

Car Inquiries

Purchaser	No. of cars	Type of car	Builder
Board of Transportation, City of New York	500[3]	Steel pass.	....
	20[3]	Trucks	....
Key System, Ltd.	40[4]	2-car articulated units	....
		14 single-body car units	....

Locomotive Orders

Road	No. of locos.	Type of loco.	Builder
Belt Ry. of Chicago	2	100-ton Diesel-elec.[5]	American Loco. Co.
Nat'l Ry. Mexico	5	4-8-0	Baldwin Locomotive Works
U. S. Navy Dept. (Bureau Supplies and Accounts)	2	300-hp. Diesel elec. switcher[5]	American Loco. Co.

Locomotive Inquiries

Road	No. of locos.	Type of loco.	Builder
Tientsin-Pukow[6]	16	2-8-2 or 2-8-4	....

[1] Work to begin in June at the Galesburg (Ill.) shops. Cor-Ten steel will be used in the bolsters, cross bearers, center sills and cover plates, while one end of each of 50 cars will be constructed of the same material. This road is also contemplating the construction of 250 hopper cars in its own shops.

[2] The Transit Commission has been asked to approve these orders.

[3] Bids open until 11:30 A.M. D.S.T. May 28.

[4] These are in addition to the inquiry for 10 to 25 2-car units reported in the January issue.

[5] McIntosh & Seymour engines.

[6] Heng-Ju Kao is director of the Tientsin, China, office and Wei Ch'iu is the chief commissioner.

Progress in Air-Conditioning Programs

Road	No. of Cars	Type of car	Type of system	Builder
Baltimore & Ohio	118[1]	....	....	....
Pennsylvania	34 sets	500-amp.-hr. batteries[2]	....	Gould Storage Battery Corp.
R. F. & P.	3 sets	Air-conditioning equip.[3]	....	Pullman-Std. Car Mfg. Co.
Southern	150[4]	Pullman, sleepers	....	Pullman Co.
	25[4]	Diners	Steam eject	Safety Car Htg. & Ltg. Co.

[1] These additional air-conditioned cars—which will bring the total number of air-conditioned cars in B. & O. service to 401, including 31 on its subsidiary, the Alton—will enable the company to operate practically all its long-distance trains thus equipped throughout. The installation on both B. & O. and Pullman cars involved is to be of B. & O. standard for air-conditioning equipment, to be manufactured by the York Ice Machinery Corporation, York, Pa., Fairbanks, Morse & Company, Chicago, and others, and is being installed by the railroad's forces at its shops at Mount Clare, Baltimore, Md.; Washington, Ind., and Bloomington, Ill.

[2] To be used in connection with the Pennsylvania's present air-conditioning program.

[3] To be installed in coaches in R. F. & P. shops.

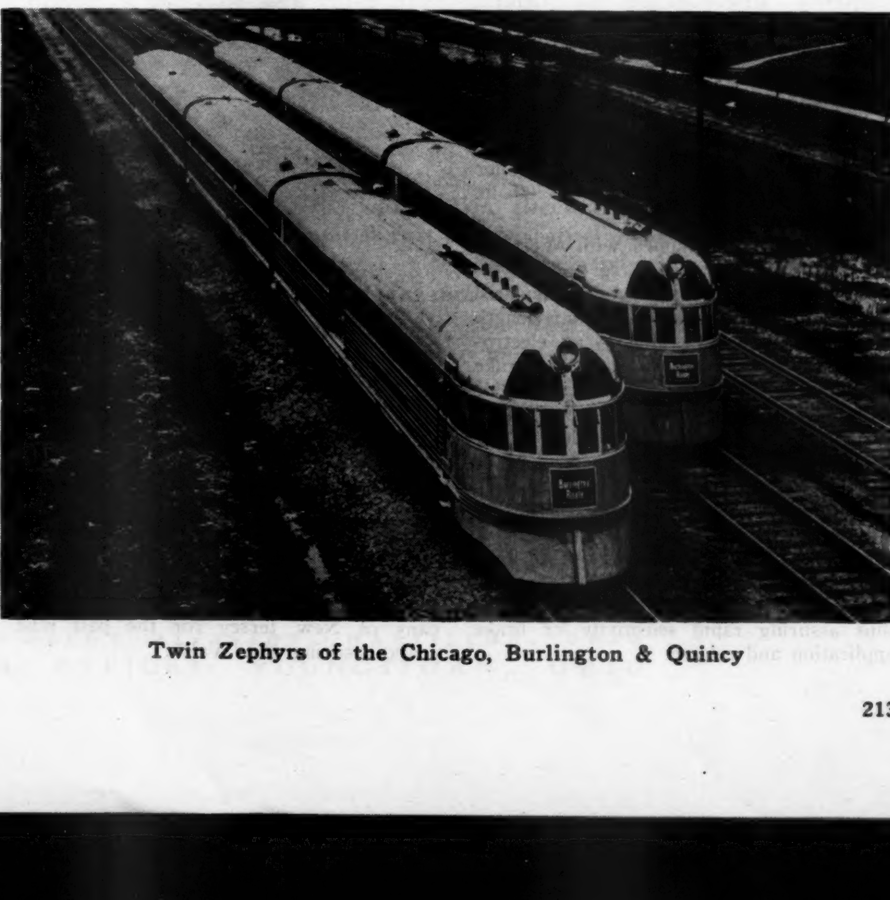
[4] To be ready for service June 1. The diners are being equipped in the Southern's own shops.

Twin Zephyrs Now in Service between Chicago and Twin Cities

THE Twin Zephyrs of the Chicago, Burlington & Quincy are now operating in regular service between Chicago and St. Paul, Minn., on a schedule of 6½ hr., or 390 min. for the 431 miles—at an average speed of 66.3 m.p.h. and a top speed of about 90 m.p.h.

On March 23, before being placed in regular service, the first of these three-car, articulated trains, No. 9901, carrying 88 passengers, left the plant of the Edward G. Budd Manufacturing Company at North Philadelphia, Pa., for a trip over the Seaboard Air Line to points in Florida. On this run of 2,861.3 miles, $43.72 worth of fuel oil was consumed.

On April 6, this same train set a record by covering the 431 miles between Chicago and St. Paul in 5 hr. 33 min., or at an average speed of 77.7 m.p.h. The occasion was a trial run with railway officers on board to test the train and track prior to the inauguration of regular service. The train left Chicago at 8:10 a. m. and arrived at St. Paul at 1:43 p. m. At one time during the run, the train reached a speed of 104 m.p.h. The fuel performance was 2.6 miles per gal. of fuel oil



Twin Zephyrs of the Chicago, Burlington & Quincy

burned in the Diesel engine, and the lubricating oil consumption was 2 gal. for the round trip. The return run was completed at 8:12 p. m. on the same day.

Except for changes in certain important details, such as the floor plans, insulation, heating arrangement, air-brake equipment, etc., the Twin Zephyrs, No. 9901 and 9902, are replicas of the first Zephyr No. 9900, described in the May, 1934, issue of the *Railway Mechanical Engineer*. The trains, built by the Edward G. Budd Manufacturing Company, Philadelphia, Pa., embody the familiar Budd Shotweld stainless steel construction, and are driven by Winton 660-hp., two-cycle, 8-in. by 10-in., eight-in-line Diesel engines, furnished by the Electro-Motive Corporation, the new railroad division of General Motors.

Each of the Twin Zephyrs, designed for high-speed, day travel only, consists of three articulated body sections, carried on four 4-wheel roller-bearing trucks. The train is 197 ft. long, weighs 225,000 lb. ready for service, and has a seating capacity for 88 passengers. The principal difference between it and the first three-car train of this type built is the elimination of a 31½-ft. mail compartment, not required on the St. Paul run, and the utilization of this space for baggage and express, also providing room for a more commodious kitchen, pantry and lunch counter and additional seating space to accommodate 16 more passengers than was possible in the first train.

Interior decorations have been carried out with the same luxuriousness of appointment as on the original Zephyr. The color scheme is characterized by the use of plain but distinctive pastel shades of green, blue and grey, blending harmoniously with the drapery, upholstery and carpets, relieved only by continuous bands of stainless steel moldings above and below the windows. Reflected light from tubular ducts in the ceiling provides diffused illumination of suitable intensity at eye level.

The three passenger compartments are completely air-conditioned by General Electric mechanical equipment. The compressor and condenser units are housed beneath the floor of two cars, while the evaporators and the distributing fans are built into the roof above the vestibules.

Steam heat of the Vapor type is provided by an oil-fired Peter Smith boiler with an evaporative capacity of 500 lb. per hr.

The trains are equipped with Westinghouse air brakes which have been developed for use with high-speed, articulated train units and are adaptable to any length of multi-unit train. This is an electro-pneumatic brake with a straight-air brake available in case of electric failure, or failure of the straight-air service brake. The electric feature—not provided on the first Zephyr—gives simultaneous brake application on each of the four trucks an appreciable interval of time (fraction of a second) sooner than was possible on the first train. The brake operation is initiated from the brake valve in the usual manner, the valve being self-lapping and thus assuring rapid sensitivity of brake application and release.

Supply Trade Notes

William M. Hager has been elected a vice-president of the American Car & Foundry Company, New York, and Howard C. Wick has been appointed assistant to the president, continuing also as secretary of the company.

Thomas Prosser & Son, New York, importers and distributors of Widia Cemented Carbides, has opened a new office at 7310 Woodward avenue, Detroit, Mich. E. R. S. Reeder is district manager, in charge of the new office.

John R. Tillman, for a number of years head of the tool engineering of the Bullard Company, Bridgeport, Conn., has been appointed assistant to Dudley B. Bullard, vice-president in charge of engineering. In his new capacity of chief executive engineer Mr. Tillman has the supervision of all departments of engineering.

F. W. Sullivan has been appointed general manager of the Railroad Division of the Socony-Vacuum Oil Company, New York; R. R. Vinnedge remains as manager of eastern railroad sales, with headquarters at New York, and C. E. Manierre, recently appointed, heads the western organization operating out of Chicago. Mr. Sullivan was graduated from Lafayette College in 1908 and subsequently was awarded an M.A. degree by Columbia University. He started work with the Vacuum Oil Company 18 years ago and for 15 years handled the indirect markets. Mr. Sullivan made a study of railroad requirements from a lubrication standpoint, and has a wide experience as an executive in the Socony-Vacuum advertising and marketing departments.

F. W. Sullivan

R. A. Greene has been appointed acting manager of the railroad sales department of the Standard Oil Company of New Jersey, New York, succeeding the late William F. Walsh. Mr. Greene, formerly with the Chicago & Alton and the Galena Signal Oil Company, has been associated with the Standard Oil Company of New Jersey for the past nine years, assisting Mr. Walsh.

Hynes Sparks has been appointed manager of eastern sales of the Symington Company and the Gould Coupler Company, with headquarters at New York. Mr. Sparks was for a number of years assistant vice-president of both these companies at New York.

Walter E. Barnes, assistant to general manager of sales of the Lukens Steel Company, Coatsville, Pa., has been appointed assistant to vice-president in charge of sales. Mr. Barnes joined the Lukens organization in 1910. After spending six years in the mills he later served in the order and sales departments.

Walter E. Barnes

The Worthington Pump & Machinery Corporation, Harrison, N. J., has created an Eastern Oil Power division which will cover its Diesel and gas engine lines in the Eastern district, under the field management of Ray L. Howes, with headquarters at 2 Park avenue, New York.

H. H. Hale of the H. H. Hale Company, San Francisco, Cal., has been appointed representative for the Pacific Coast region of the Graham-White Sander Corporation, Roanoke, Va. Mr. Hale was formerly master mechanic of the Southern Pacific and later superintendent of motive power of the Cincinnati, Hamilton & Dayton, now part of the Baltimore & Ohio. Among other supply lines, Mr. Hale represents the Galena Signal Oil Company on the Pacific Coast.

John Cornish, sales engineer of The Miller Company, Meriden, Conn., is now located in the Philadelphia, Pa., office of the Electric Service Supplies Company. This is a further step in the co-operative arrangement of these two companies which brings together their knowledge and experience in the field of transportation lighting, and their new designs of lighting equipment for trains, cars and buses.

C. B. Armstrong has been appointed railroad sales manager, Central division of the Air Reduction Sales Company, with office at Chicago, succeeding B. N. Law, deceased. Mr. Armstrong has been associated with the company since October

(*Continued on next left-hand page*)

1, 1920, having first been employed in its sales department at Pittsburgh, Pa. In the spring of 1925, he was transferred to the general offices of the company at New York, where he was soon appointed general sales manager of one of its affiliated companies, which position he was holding at the time of his recent appointment to the railroad sales department at Chicago.

A. J. O'Leary has been appointed assistant to general manager of sales of the Lukens Steel Company, Coatesville, Pa. Prior to joining the Lukens organization in 1916, he was with the Pennsylvania Railroad and Alan Wood Steel Company.

The Jones & Laughlin Steel Corporation, Pittsburgh, Pa., elected three new directors at its annual meeting; one to fill a vacancy, and two to occupy additional directorships created by action of the stockholders. The new members of the board are: Dwight Clark, treasurer of the Phillips Properties, Inc.; William B. Todd, who was elected vice-president in charge of sales as well as a director, and who has been general manager of sales of the corporation since 1931; F. E. Fieger, who since 1929 has been general manager, was made a director, a member of the executive committee, and vice-president in charge of manufacturing operations.

Mr. Todd, vice-president in charge of sales, had previously served with the Union Drawn Steel Company. He resigned as vice-president of the latter in 1922 to go with Jones & Laughlin as manager of its cold finished sales division. In 1930 he was appointed assistant general manager of sales and since 1931 had been general manager of sales of the corporation.

William B. Todd

Obituary

John Hill Whiting, chairman of the board of the Whiting Corporation, Harvey, Ill., died on April 6 at the age of 84.

George Nibbe, special representative of the Inland Steel Company, died suddenly on April 3.

W. H. Snedaker, vice-president of the Griffin Wheel Company, Chicago, with headquarters at San Francisco, Cal., died in that city on April 19 of a complication of ailments.

Edward Morton McIlvain, who was for many years in the iron and steel business and formerly from 1901 to 1906 president and a director of the Bethlehem Steel Company, died on April 18 at his home in New York at the age of 72.

Daniel J. Whalen, general manager of the Canton plant of the Pullman-Standard Car Manufacturing Company, died on April 18 at the age of 56. Mr. Whalen had been in the car-building industry for 40 years, having served for a number of years at the Milton (Pa.) tank car plant of the American Car & Foundry Company, then with the Pressed Steel Car Company at Pittsburgh, Pa. He then went to the Canton Car Company, serving as general manager and later as general manager of the same plant, with its successors, the Pullman-Standard Car Manufacturing Company.

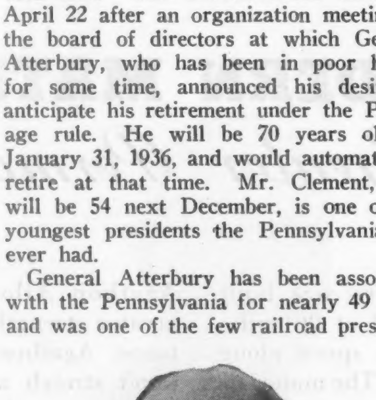
John A. Talty, special engineer of the Franklin Railway Supply Company, Inc., died at his home in Buffalo, N. Y., on April 19. Mr. Talty spent his early boyhood on a farm, starting his railroad work as a waterboy on the Erie. In 1873 he became a freight brakeman on that road and served successively as fireman and engineman. He then became an instructor on the air brake for the Westinghouse Company, in charge of its instruction car, and later was employed in a similar position with the International Correspondence Schools. From 1900 to 1910 he was president of the Traveling Engineers' Association. In 1910 he became assistant supervisor of equipment for the Public Service Corporation of New York, later becoming assistant superintendent. Mr. Talty became special engineer of the Franklin Railway Supply Company in 1921.

Personal Mention

General

General W. W. Atterbury, president of the Pennsylvania since October 1, 1925, has resigned and M. W. Clement, formerly vice-president, and acting president since last July, has been elected to succeed him. The announcement came on April 22 after an organization meeting of the board of directors at which General Atterbury, who has been in poor health for some time, announced his desire to anticipate his retirement under the P.R.R. age rule. He will be 70 years old on January 31, 1936, and would automatically retire at that time. Mr. Clement, who will be 54 next December, is one of the youngest presidents the Pennsylvania has ever had.

General Atterbury has been associated with the Pennsylvania for nearly 49 years and was one of the few railroad presidents of this country who came up through the mechanical department.



Gen. W. W. Atterbury

William Wallace Atterbury was born at New Albany, Ind., on January 31, 1866, and spent his boyhood in Detroit, Mich. He was graduated from Yale University in 1886 with the degree of Bachelor of Philosophy. He entered the service of the Pennsylvania Railroad on October 11 of the same year as an apprentice in the Altoona shops. From 1889 to 1892 he served as assistant road foreman of engines on various divisions of the Pennsylvania and the Philadelphia, Baltimore & Washington. In 1892 he was promoted to assistant engineer of motive power in the Pennsylvania Company, Northwest System. From 1893 to October 26, 1896, he was master mechanic at Fort Wayne, Ind. On the latter date, he was promoted to superintendent of motive power with headquarters at Altoona, and on October 1, 1901, was advanced to the position of general superintendent of motive power of the Lines East of Pittsburgh and Erie.

General Atterbury's affiliation with the transportation department dates back to January 1, 1903, when he was appointed general manager of the Lines East of Pittsburgh and Erie. On March 24, 1909, he was elected fifth vice-president in charge of transportation and on March 3, 1911, upon a change in the organization, was elected fourth vice-president and a director. The practice of designating the several vice-presidents by number was changed on May 8, 1912, at which time Mr. Atterbury was elected vice-president in charge of operation, his jurisdiction still covering at that time the lines East of Pittsburgh. From May 17, 1916, to June, 1919, he was also president of the American Railway Association.

Recognition of Mr. Atterbury's ability as a transportation officer was particularly signalized by his being requested by Secretary of War Newton D. Baker, shortly after war was declared against Germany, to go to France and assume charge, as director-general of transportation of the American Expeditionary Forces, of the details of organization of the American rail-

(Continued on next left-hand page)

way transportation facilities in France. He sailed for Europe in August, 1917. On October 5, 1917, he was commissioned a brigadier-general and his appointment as such was confirmed by Congress three days later. General Atterbury returned to the United States on May 31, 1919, after having set up a record of performance for which American railway men have never been called upon to make any apologies. He was made the recipient of the distinguished service medal of the United States, was made a commander of the Legion of Honor by France, a companion of the Most Honorable Order of the Bath by Great Britain, and a commander of the Order of the Crown by Belgium.

Upon the termination of federal control, General Atterbury resumed his duties as vice-president in charge of operation of the Pennsylvania, but this time having jurisdiction over the entire system as a result of the creation of the new plan of organization into regions. He continued in this capacity until November 15, 1924, when he was elected vice-president of the corporation without designation, so that he might act in a more general executive capacity, aiding the president in his administrative duties and acting for the president in his absence. On October 1, 1925, he was elected president to succeed Samuel Rea.

General Atterbury is an honorary member of the American Society of Mechanical Engineers, a member of the American Academy of Political and Social Science and the American Philosophical Society. He has been awarded honorary LL.D. degrees by the University of Pennsylvania (1919), Yale University (1926) and Villa Nova (1927).

F. J. Jumper, inspection engineer on the Union Pacific, has been appointed to the newly-created position of assistant general mechanical engineer, with headquarters at Omaha, Neb.

Fulton Lyon Dobson has been appointed general fuel manager of the Pennsylvania at Philadelphia, Pa. Mr. Dobson was born at Greensburg, Pa., on October 19, 1887. He attended public schools in Greensburg and Wilkinsburg, Pa., and was graduated from Purdue University with the degree of B.S. in M.E. in 1908. He entered railway service with the Pennsylvania as laborer, serving in this capacity during the summers of 1901 and 1902. From 1903 to 1908 he served in various capacities, being furloughed during school terms. From 1908 to 1910 he served as a special apprentice at the Altoona, Pa., shops and from 1910 to 1913 as inspector of the Philadelphia Terminal and Buffalo divisions. In November, 1913, he was appointed assistant master mechanic at Jersey City; in 1915, general foreman at Buffalo, N. Y., and in 1916, assistant engineer, motive power, at Williamsport, Pa., serving in a similar capacity at Altoona in 1917. From 1918 to 1927, Mr. Dobson served successively as master mechanic of the Williamsport division and of the New York division. In January, 1927, he was appointed assistant superintendent of the New York division at Jersey City, N. J.; in March, 1927, superintendent of the Schuylkill division at Reading, Pa.; in June, 1929, acting division superintendent at Pittsburgh, Pa., and in November of the same year he was appointed division superintendent there. In

F. L. Dobson

July, 1933, he was appointed general superintendent of the Lake division at Cleveland, Ohio, the position he held until his recent appointment.

Master Mechanics and Road Foremen

H. M. Allan, master mechanic of the Canadian Pacific at Vancouver, B. C., has been transferred to the Alberta district, with headquarters at Calgary, Alta., to succeed M. J. Scott, who has retired.

Harry B. Feather, general enginehouse foreman of the Louisville & Nashville, has been appointed master mechanic, with headquarters at Corbin, Ky., succeeding the late Fred W. Oakley. Mr. Feather was born on January 12, 1898, at Corbin. He entered the service of the L. & N. on June 1, 1913, as a machinist apprentice, completing his apprenticeship at the South Louisville shops April 26, 1915. He was promoted to the position of machinist on

H. B. Feather

September 17, 1917; machinist leader, Corbin shops, October 16, 1917; gang foreman, July 1, 1918; assistant enginehouse foreman, December 1, 1919; enginehouse foreman, March 16, 1921; and general foreman, November 1, 1921. His appointment as master mechanic on February 1 of this year placed him in the position held by his father, H. Feather, Sr., from 1912 until his death in May, 1929.

Shop and Enginehouse

Alexander B. Colville, who has been appointed superintendent of shops of the Great Northern at Hillyard, Wash., was born in Scotland on December 22, 1883. On October 25, 1898, he entered the shops of the Great Northern at Hillyard as a boilermaker apprentice. From October 25, 1899, until October 25, 1903, he served as a machinist apprentice, on the latter date becoming a machinist. He was gang foreman and machine foreman at Hillyard from June 10, 1907, to October 18, 1915. He then went to Portland, Oregon, as general foreman of terminals of the Spokane, Portland & Seattle, with which road the Great Northern is affiliated. He returned to Hillyard on October 1, 1917, as general foreman, and on March 1 of this year became superintendent of shops.

William S. Eyerley, who has been appointed superintendent of shops of the Baltimore & Ohio at Mount Clare, Baltimore, Md., was born on December 5, 1875, at Baltimore. He was educated in the public schools of that city and completed an International Correspondence School course in locomotive and mechanical engineering in 1900. He entered the service of the B. & O. on March 1, 1891, as a messenger; became an apprentice on March 1, 1892; a machinist on April 1, 1896; gang leader, November 5, 1910; foreman No. 2 machine shop, May 1, 1916; general foreman locomotive shops, April 1, 1918; assistant superintendent of shops, October 16, 1918, and superintendent of shops on March 1 of this year.

Car Department

D. M. Raymond, general foreman of the car department of the Union Pacific at Council Bluffs, Iowa, has been appointed general car inspector, with headquarters at Omaha, Neb.

A. L. Looney, formerly general car inspector of the Union Pacific at Omaha, Neb., has been appointed superintendent of the car department with the same headquarters.

Purchasing and Stores

F. B. Matthews has been appointed purchasing agent for the Minneapolis & St. Louis, with headquarters at Minneapolis, succeeding E. C. Hoffman, resigned.

Obituary

Fred W. Oakley, master mechanic for the Louisville & Nashville, with headquarters at Corbin, Ky., died on January 25 at the age of 57.

Frederick I. Plechner, who retired about a year ago as purchasing agent of the Great Northern at St. Paul, Minn., died in that city on March 22.

Horace J. McQuade, a former purchasing agent of the Lehigh Valley, who retired in 1932, died on March 26 at his home in South Orange, N. J.